TABLE OF CONTENTS

TABLE OF CONTENTS

TABLES

FIGURES

FIGURES

FIGURES

FIGURES

STRATEGIC LANDSCAPE

STRATEGIC LANDSCAPE

NASA's historic and enduring leadership and cutting edge roles for the nation fall within three major strategic thrusts: discovery, exploration, and development. NASA's activities make advances that contribute to fundamental national purposes and goals that align to the core focus areas of our Mission Directorates (Science, Human Exploration and Operations, Space Technology, and Aeronautics Research). In addition, the Agency has a number of activities and support areas, including those in its Mission Support Directorate that enable NASA's missions. NASA's strategic landscape continues to be characterized by six major elements:

- Global Engagement and Diplomacy
- National Security
- Leadership and Inspiration
- Economic Development and Growth
- Expanding Scientific Knowledge
- Addressing Societal Challenges

These elements represent a synthesis of major themes from the Agency's founding charter, the 1958 Space Act, to more recently, with the White House (National Space Policy of the United States of America), Congress (NASA Authorization Act of 2010) and independent sources (National Research Council reports 'America's Future in Space' and, 'Pathways to Exploration: Rationales and Approaches for a U.S. Program of Human Space Exploration').

AGENCY OPERATIONS

AGENCY OPERATIONS

NASA'S VISION, MISSION, AND STRATEGIC GOALS

NASA STRATEGIC PLAN - *https://www.nasa.gov/sites/default/files/files/FY2014_NASA_SP_508c.pdf*

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

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

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

Figure 4.1 NASA Centers and Facilities Map

NASA ORGANIZATION

NASA's organization is shown in Figure 4.2 below, and consists of NASA Headquarters in Washington, DC, nine centers and associated component facilities located around the country, and the Jet Propulsion Laboratory, a federally funded research and development center operated under a contract with the California Institute of Technology. The Headquarters is organized into an Office of the Administrator, Administrative Staff Offices, four Mission Directorates, and the Mission Support Directorate. Image of NASA org – nasa.gov

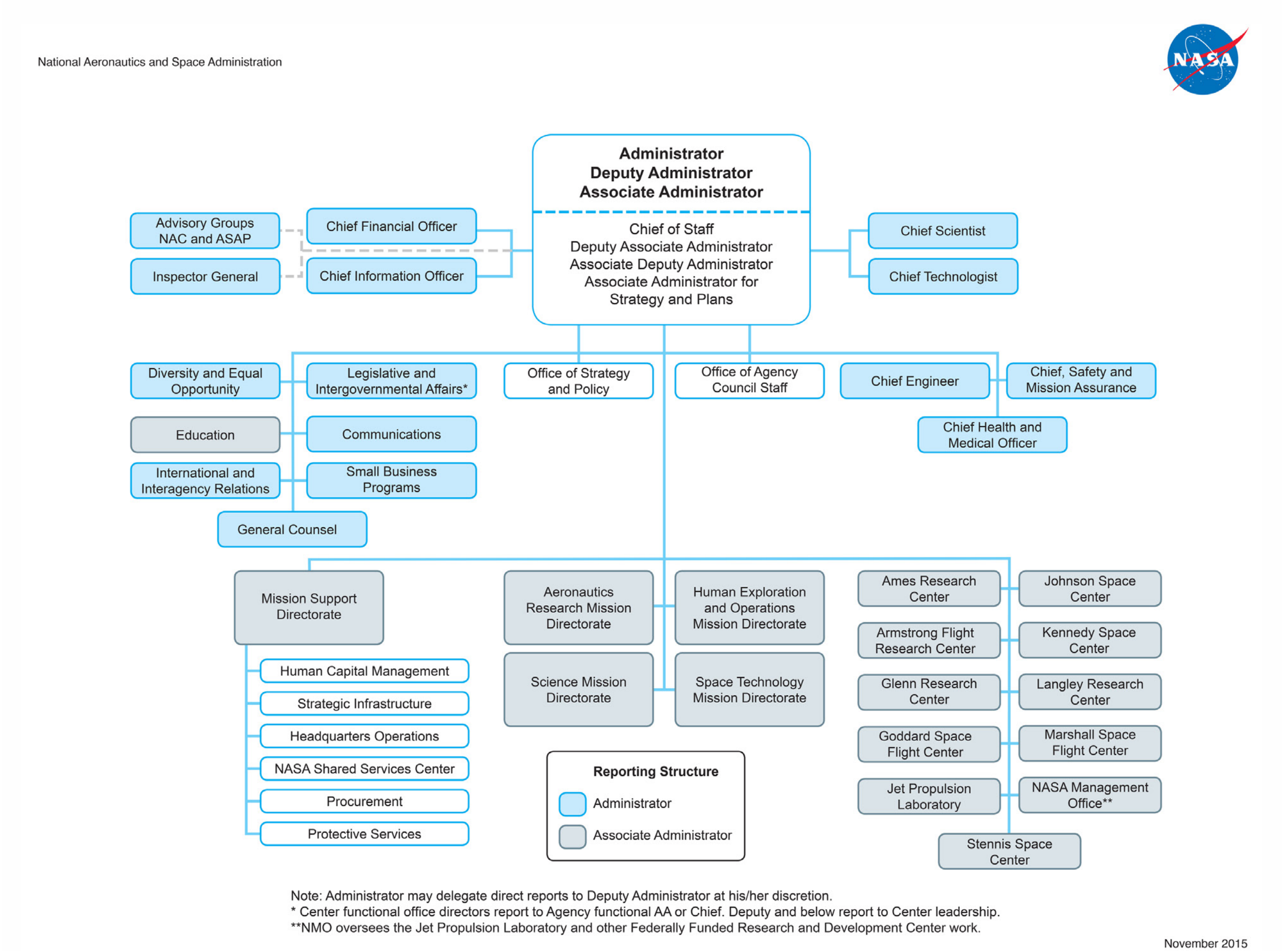


Figure 4.2 NASA Organization

See ***SECTION 12*** and ***SECTION 13*** for detailed information on the functions and leadership of NASA HQ Offices, Mission Directorates, and Centers.

AGENCY LEADERSHIP: OFFICE OF THE ADMINISTRATOR

MISSION STATEMENT

The Office of the Administrator provides overall leadership, planning, policy direction, management, and coordination for all NASA activities.

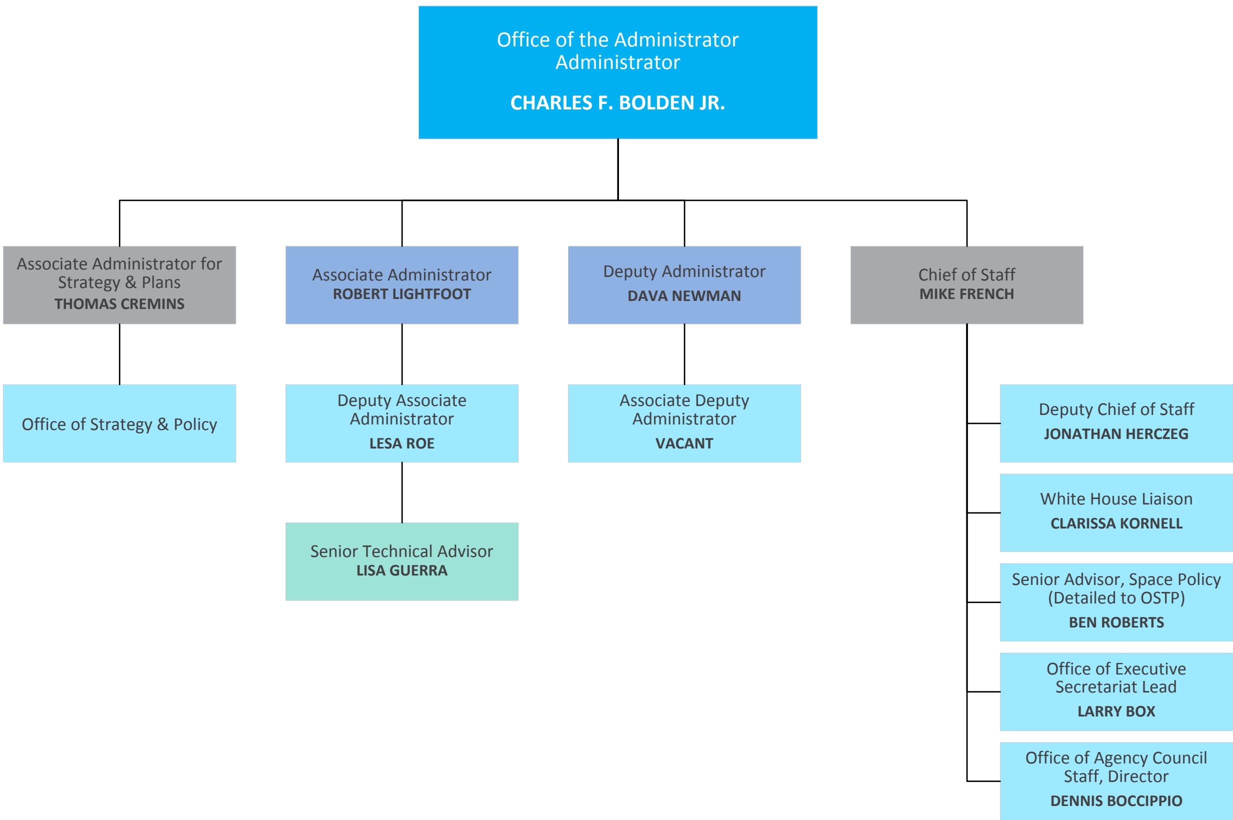


Figure 4.3 Agency Leadership

LEADERSHIP

NASA ADMINISTRATOR

MISSION STATEMENT

The Administrator leads the Agency and is accountable to the President for all aspects of the Agency's mission, including establishing and articulating the Agency's vision, strategy, and priorities and overseeing successful implementation of all supporting policies, programs, activities, and performance assessments. As part of exercising oversight, all Technical and Institutional Authorities (Agency Chiefs) report to the Administrator. The Administrator performs all necessary functions to govern NASA operations and exercises the powers vested in NASA by law.

OFFICIAL IN CHARGE

MAJ. GEN. CHARLES FRANK BOLDEN, JR.

SPECIAL ROLES: Chair: Executive Council, Chair: Senior Management Council

Charles F. Bolden Jr., Major General, USMC (Retired), is the 12th Administrator of the National Aeronautics and Space Administration (NASA). At NASA, Bolden has overseen the safe transition from 30 years of space shuttle missions to a new era of exploration focused on full utilization of the International Space Station and space and aeronautics technology development. The Agency's dynamic science activities under Bolden include an unprecedented landing on Mars with the Curiosity rover, the launch of a spacecraft to Jupiter, enhancing the nation's fleet of Earth-observing satellites, continued progress toward the 2018 launch of the James Webb Space Telescope (the successor to the Hubble Space Telescope), and the successful launch and recovery of the Orion deep-space crew module, the first human-rated spacecraft to be developed for flight beyond low-Earth orbit by any nation in more than 40 years. His 34-year career with the Marine Corps included 14 years as a member of NASA's Astronaut Office. He traveled to orbit four times aboard the space shuttle, commanding two missions and piloting two others, including STS-31, on which Hubble was deployed. After his final shuttle flight in 1994, he left NASA to return to active duty with the Marine Corps. He was promoted to major general in July 1998 and retired from the Marine Corps in 2003. He received his Bachelor of Science degree from the U.S. Naval Academy and his Master of Science degree from the University of Southern California.

EXTENDED BIO - *http://www.nasa.gov/about/highlights/bolden_bio.html*

LEADERSHIP

NASA DEPUTY ADMINISTRATOR

MISSION STATEMENT

The Deputy Administrator advises the Administrator on overall leadership, planning, and policy direction for the Agency. The Deputy Administrator performs the duties and exercises the powers delegated by the Administrator. The Deputy Administrator acts for the Administrator in his or her absence by performing all necessary functions to govern NASA operations and exercise the powers vested in NASA by law.

OFFICIAL IN CHARGE

DR. DAVA NEWMAN

SPECIAL ROLES: Chair: Partnership Council, Alternate Chair: Executive Council and Senior Management Council

Dr. Dava Newman was nominated by President Barack Obama in January 2015 and confirmed by the U.S. Senate in April 2015 to serve as the Deputy Administrator of the National Aeronautics and Space Administration. She began her duties with the Agency on May 18, 2015. Prior to her tenure with NASA, Newman was the Apollo Program Professor of Astronautics at the Massachusetts Institute of Technology (MIT) in Cambridge. Her expertise is in multidisciplinary research that encompasses aerospace biomedical engineering. Newman's research studies were carried out through space flight experiments, ground-based simulations, and mathematical modeling. Her latest research efforts included advanced space suit design, dynamics and control of astronaut motion, and socio-technical systems analysis and space policy. She also had ongoing efforts in assistive and wearable technologies to augment human locomotion here on Earth. Newman is the author of Interactive Aerospace Engineering and Design, an introductory engineering textbook published by McGraw-Hill, Inc. in 2002. She also has published more than 250 papers in journals and refereed conferences. She has served on numerous National Academies' studies and panels on human spaceflight, human-robotic interaction and active learning for engineering and design education. As a student at MIT, Newman earned her Ph.D. in aerospace biomedical engineering in 1992 and Master of Science degrees in aerospace engineering and technology and policy in 1989. She earned her Bachelor of Science degree in aerospace engineering from the University of Notre Dame in 1986.

EXTENDED BIO - *http://www.nasa.gov/about/highlights/newman_bio.html*

AGENCY OPERATIONS

LEADERSHIP

ASSOCIATE ADMINISTRATOR

MISSION STATEMENT

The Associate Administrator performs the duties and exercises the powers delegated by the Administrator and acts for the Administrator in the absence of the Administrator and Deputy Administrator. The Associate Administrator is responsible for integrating the technical and programmatic elements of the Agency, and oversees the Agency's Centers, programs, Technical Authorities, and the NASA Management Office. Additional responsibilities include overseeing the planning, directing, organization, and control of the day-to-day Agency technical and programmatic operations, including establishing controls over Agency activities, providing a means for evaluating mission

OFFICIAL IN CHARGE

ROBERT M. LIGHTFOOT JR.

SPECIAL ROLES: Chair: Program Management Council

Robert M. Lightfoot Jr. became Associate Administrator for NASA, the agency's highest-ranking civil servant position, effective Sept. 25, 2012. Lightfoot serves as NASA's Chief Operating Officer and oversees Agency operations across all technical and programmatic activities. NASA's Center Directors and Mission Associate Administrators report directly to Lightfoot. He also stewards the overall senior executive corps. He previously was director of NASA's Marshall Space Flight Center in Huntsville, Ala. Named to the position in August 2009, he headed one of NASA's largest field installations, playing a critical role in NASA's space operations, exploration and science missions. He served as acting director of the center from March 2009 until his appointment as director. From 2007 to 2009, Lightfoot was deputy director of the Marshall Center. Lightfoot served as manager of the Space Shuttle Propulsion Office at Marshall from 2005 to 2007. From 2003 to 2005, he served as assistant associate administrator for the Space Shuttle Program in the Office of Space Operations at NASA Headquarters in Washington. In 2002, Lightfoot was named director of the Propulsion Test Directorate at NASA's Stennis Space Center. Lightfoot began his NASA career at the Marshall Center in 1989 as a test engineer and program manager for the space shuttle main engine technology test bed program and the Russian RD-180 engine testing program for the Atlas launch vehicle program. Lightfoot received a bachelor's degree in mechanical engineering in 1986 from the University of Alabama. In 2010, he was inducted into the State of Alabama Engineering Hall of Fame. Lightfoot has received numerous awards during his NASA career, including a NASA Outstanding Leadership medal in 2007 for exemplary leadership of the Shuttle Propulsion Office. In 2006, he was awarded the Presidential Rank Award for Meritorious Executives, and in 2010 he received the Presidential Rank Award for Distinguished Executives. In 2000, Mr. Lightfoot received a Spaceflight Leadership Recognition Award. In 1999, NASA's astronaut corps presented him with a Silver Snoopy Award.

EXTENDED BIO - *http://www.nasa.gov/about/highlights/lightfoot_bio.html*

LEADERSHIP

DEPUTY ASSOCIATE ADMINISTRATOR

MISSION STATEMENT

The Deputy Associate Administrator is responsible for integrating the mission support elements of the Agency. The Deputy Associate Administrator oversees the Agency's mission support functions through the Mission Support Directorate, Centers, and appropriate staff offices. The Deputy Associate Administrator also performs the duties and exercises the powers delegated by the Associate Administrator and acts for the Associate Administrator in the absence of the Associate Administrator.

OFFICIAL IN CHARGE

LESA ROE

SPECIAL ROLES: Chair: Mission Support Council

Appointed as NASA's deputy associate administrator in May 2014, Lesa Roe assists the Associate Administrator in performing the Agency's chief operating officer duties and is leading an Agency-wide initiative across all of NASA's Centers to establish a more efficient operating model that maintains a minimum set of capabilities and meets current and future mission needs. Roe has had a long and distinguished career that includes positions at multiple NASA Centers, including her most recent post as the director of NASA's Langley Research Center. Prior to Langley, she served as manager of the International Space Station Research Program at Johnson Space Center in Houston, where she led the efforts of more than 900 engineers and scientists on the $450 million annual research program, delivering the first research to the space station. In her more than 15 years of program and project management at Kennedy Space Center in Florida, Roe developed systems and flight tests for flight elements that are now in orbit as part of the space station. Her engineering career began in the private sector, performing satellite communications analysis. She holds a Bachelor of Science degree in Electrical Engineering from the University of Florida and a Master of Science degree in Electrical Engineering from the University of Central Florida. Her honors include the 2015 Senior Executive Service Presidential Distinguished Rank Award and the 2006 Presidential Meritorious Executive Rank Award, NASA Exceptional Service Medal, University of Florida's Distinguished Career Achievement and Outstanding Leadership in Engineering Awards, the 2010 Women in Aerospace Leadership Award, the 2010 YWCA Women of Distinction in Science and Technology, the Virginia Hispanic Chamber of Commerce 2012 Bridge Builder Award, and selection by WOW Magazine as one of the nation's top 90 women for mentoring women with potential without resources.

EXTENDED BIO - *http://www.nasa.gov/feature/lesa-roe*

LEADERSHIP

CHIEF OF STAFF

MISSION STATEMENT

The Chief of Staff is responsible for coordinating the management and execution of initiatives, programs, and policies in critical areas of concern to the Administrator and ensuring that the strategic goals and objectives established by the Administrator are achieved. The Chief of Staff directs the Office of the Administrator, oversees the Office of the Agency Council Staff, and also serves as a liaison to the White House staff.

OFFICIAL IN CHARGE

MICHAEL FRENCH

Michael French serves as NASA's chief of staff and as a senior advisor to NASA Administrator Charles F. Bolden, Jr. Before becoming Chief of Staff in October 2014, French served as Deputy Chief of Staff, beginning in May 2012. Prior to joining NASA in 2011, French served as Senior Advisor to the Secretary of the Interior, as Deputy Director of Cabinet Affairs at the White House, and as Counsel to the Chairman of the Federal Election Commission. Prior to working in the federal government, French practiced law in the defense-aerospace sector as an attorney in Los Angeles. In 2008, French served as an in-house counsel to the Obama for America campaign and as an attorney to the Obama-Biden Presidential Transition Team. French earned his bachelor's degree in business administration from the Haas School of Business at the University of California, Berkeley. He also holds a J.D. from Harvard Law School.

EXTENDED BIO - *http://www.nasa.gov/about/highlights/french_bio.html*

LEADERSHIP

ASSOCIATE ADMINISTRATOR FOR STRATEGY & PLANS

MISSION STATEMENT

The Associate Administrator for Strategy and Plans directs the Office of Strategy and Policy. The Associate Administrator for Strategy and Plans is responsible for coordinating strategy implementation and policy integration activities in support of the Administrator and for policy integration.

OFFICIAL IN CHARGE

THOMAS E. CREMINS

Thomas Cremins joined the Office of the Administrator in April of 2014 and became the Associate Administrator for Strategy and Plans in November 2015. Before that, he worked in a range of critical and leading-edge governmental and executive assignments. Previously, Cremins served as the Director, Legislative Liaison Division, at NASA Headquarters. Between September 2008 and December 2010, he served as the Director, Studies and Analysis Division in the NASA administrator's office. In 2010, as a fellow on the Senate Commerce Committee, he played an instrumental role in the development and passage of the 2005 and 2010 NASA Authorization Acts. Cremins led strategy and corporate management of the space operations mission directorate and served as the deputy assistant administrator for policy and management at the exploration systems mission directorate. He led senior-level negotiations among International Space Station (ISS) and international agency representatives that provided recommendations to their respective governments on the scope and direction of the ISS program at the critical juncture of initial ISS operations, the Shuttle Columbia tragedy and the start of a U.S. exploration initiative. He worked at the Johnson Space Center for a decade as Assistant Center Director, Russia, and in other programmatic and management positions. He served as the lead negotiator for a number of key programmatic, contractual and policy activities between the U.S. and Russia. Before joining NASA in 1993, Cremins worked in the Office of the Secretary of the Department of Energy (DOE), Office of Space. He organized and led initiatives with the national laboratories on a range of executive level and interagency task forces. Cremins has been awarded NASA's Exceptional Achievement Medal, Outstanding Leadership Medal, Exceptional Service Medals, as well as numerous team and leadership Group Achievement Awards.

EXTENDED BIO - *http://www.nasa.gov/content/thomas-e-cremins-senior-advisor-to-the-administrator-for-strategy-and-policy-implementation*

OFFICE OF STRATEGY AND POLICY

The Office of Strategy and Policy (OSP) supports the Office of the Administrator by assessing changes in NASA's internal and external environment, identifying the options for key Agency decisions, and performing studies and analyses to ensure timely, well-informed decisions. Agency Integration, a core function of OSP, spans across several key areas: Agency Architectures, Mission Directorate Alignment, Acquisition Strategies, Capabilities Leadership and Alignment, and Strategic Workforce Planning. The Agency Integration effort facilitates the development of Level Zero/One guidance for implementing organizations. OSP, in support of the Associate Administrator, coordinate Strategy Implementation Planning (SIP) sessions

The SIP process is one mechanism that promotes long-term strategy discussions across the Agency. The SIP process represents an integrated Agency-level activity to transform high-level Agency strategy into guidance for implementing NASA's portfolio and budget planning. The SIP effectively brings together the relevant NASA representatives from the Mission Directorates, the Centers, and key Headquarters offices to discuss programmatic and/or pervasive issues that require long-term planning.

AGENCY GOVERNANCE AND GOVERNING COUNCILS

Throughout its history, NASA has maintained a number of chartered, formal governing councils for purposes of making informed, documented decisions on key strategic, programmatic and institutional questions. The configuration of NASA's strategic management system, including its governance framework, is documented in NASA Policy Directive (NPD) 1000.0B, the "root" of the NASA Directive and Regulation tree. Governance Councils are managed by the Office of Agency Council Staff (OACS), which reports to the NASA Chief of Staff.

The current governance structure core implementation relies upon an Executive Council (EC) chaired by the NASA Administrator, a virtual Senior Management Council (SMC) used to collect Agency-wide inputs on key issues, a Program Management Council (PMC) used to make key Program implementation decisions, and a Mission Support Council (MSC) used to decide key Institutional issues. Technical capability perspectives inform both PMC and MSC discussions and decisions. The Executive Council makes decisions on questions of top level NASA strategy, annual budget development, governance, organization and operating model. The primary Councils are supported by special purpose councils and reviews. The Partnership Council addresses emerging policy questions associated with increased use of industry, academia and interagency partnerships as an acquisition tool. Acquisition Strategy Meetings determine the acquisition approach for large programs and institutional functions, and provide a forum for consideration of make/buy and capability management issues. The monthly Baseline Performance Review implements routine, integrated performance management of all major Agency mission and institutional programs and projects.

ADDITIONAL RESOURCES

NPD 1000.0B NASA GOVERNANCE AND STRATEGIC MANAGEMENT HANDBOOK - *http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPD&c=1000&s=0B.*

AGENCY OPERATING MODEL INITIATIVE

In 2014, NASA embarked on an effort to strategically address the technical capabilities required to support Agency goals. Referred to as the Technical Capabilities Assessment Team (TCAT) and championed by the NASA Associate Administrator, this disciplined effort enabled NASA leadership to make informed decisions about both investing and divesting in order to ensure that the Agency has the right mix of people and assets to carry NASA's mission forward.

The TCAT efforts also provided insight into other fundamental operating model areas that needed attention, including how NASA uses its workforce, how NASA competes internally, how NASA manages its program and business practices, how NASA integrates across Mission Directorates, and how NASA accounts for technical capabilities in key decisions. In order to address these areas, a larger imperative was defined — to establish a more efficient operating model that maintains critical capabilities and meets current and future mission needs – particularly in view of continuing budget pressures on NASA's Safety, Security and Mission Services account, which supports many of these key capabilities.

In 2015, NASA concluded the formal TCAT evaluations and moved forward with the following key initiatives related to the NASA operating model:

- Establishing the Capability Leadership Model
- Initiating Business Services Assessments
- Extending Program/Project Planning
- Strategic Workforce Planning
- Taking action on internal NASA Competition Practices
- Pursuing Agency Integration

CAPABILITY LEADERSHIP MODEL

The Capability Leadership Model enables stewardship of NASA's critical capabilities, awareness by senior management of capability health, and sustainment of Center capabilities to meet mission needs. The model approach targets those capabilities that require: (a) a greater coordination and alignment across Mission Directorates and Centers; and, (b) an integrated strategy toward advancement for future Agency objectives. Capabilities are designated in the following categories: disciplines, systems, research, and services. This new construct allows for Agency-wide insight and advice around a capability's technical content, tools/methods, workforce skills, asset/facility utilization, and external disposition. Capability Leaders represent subject matter experts enabling a cultural shift toward recognition and collaboration across NASA in areas of significant importance — from propulsion systems to mission operations to Earth science research.

BUSINESS SERVICES ASSESSMENTS

Similar to TCAT, NASA initiated a series of assessments on the business side of the house. The purpose of the Business Services Assessments (BSA) is to continue efforts to find efficiencies in operating model practices. By defining the health of each business service area and identifying opportunities for optimization, the BSA enables NASA leadership to make informed decisions on investing/divesting strategically within the budget while strengthening innovation in critical areas. Four BSA deep dives are currently in the implementation phase: information technology, procurement, human capital, and facilities. Each of these business services is addressing specific decisions — ranging from governance to reducing redundancy to strengthening services. Two additional BSA deep dives are in the assessment and decision phase, including budget management, and education and outreach. Additional service areas are under consideration for assessments in 2017.

PROGRAM/PROJECT PLANNING AND ASSESSMENT

NASA deputy-level senior managers were chartered to consider streamlining internal Agency program/project management practices. The initial effort analyzed sample projects to understand if NASA was levying constraints and requirements that were above and beyond what project managers needed to actually manage their projects. They also looked at the civil service allocation process, as well as the planning and tracking of workforce assignments. Numerous recommendations are underway to enable desired efficiencies. In addition, the Deputies Team continues their assessment work with a focus on the scope and scale of the program/project management capability in the Agency, including skills requirements and levels of certification. Many of the topics addressed by the Deputies Team are also coordinated and referenced in the BSA for budget management. In 2015, the NASA Associate Administrator issued a decision memo on NASA's capability to perform independent assessments of programs and projects. The decision eliminated evaluation as a separate and external organization, while also addressing specific considerations, including the potential burden of reviews on programs/projects, the level of Mission Directorate accountability for reviews, and the use of internal talent to staff review boards. The new approach to NASA independent assessment continues to be refined and documented as program reviews continue along the established mission life cycle.

STRATEGIC WORKFORCE PLANNING

The Agency has instituted an approach to performing Strategic Workforce Planning (SWP). The intent is to improve how each Center projects their workforce capacity based on mission demands and demographic shifts. The SWP process includes determinations on the role of the civil servant, Center technical and programmatic work roles, Center mission support work roles, as well as overall guidance regarding workforce size and profile. The SWP process will be connected to the annual budget process to capture a 5-year work horizon, with a longer timeframe perspective captured in each Center's strategic workforce plan as maintained by the Office of Human Capital Management. The new features in the SWP include: (1) clarified expectations for Mission Directorates and Centers as to the type of work to be performed in-house and what services and capabilities the Agency looks to each Center to provide; (2) a framework for Mission Directorates and Centers to use for determining the role of civil servants as compared to other sectors of workforce; (3) determination of long-term workforce requirements of Centers to determine if and how to resize and reshape the workforce supply; (4) identification of demographic goals for the civil service workforce supply to support the long-term health of that workforce; and (5) integrated Agency-wide workforce plan that is communicated to stakeholders and connected to Agency human capital programs.

COMPETITION PRACTICES

Various Agency assessments noted the burden on Centers to compete openly for NASA funding, whether for scientific research, technology development, or instrument and mission implementation. A specific study as well as focused leadership attention on the issue resulted in the decision memo Internal NASA Competition Practices. With respect to research competition, the NASA Chief Scientist put in motion a revised model to fund and review the activities of internal scientists, allowing for the majority of NASA scientists to pursue directed research while meeting peer review standards. The approved model also addresses a new approach to the hiring of scientists into the NASA civil service.

With respect to mission competition, the Science Mission Directorate (SMD) is improving their Announcement of Opportunity (AO) practices. Some specific considerations for future AO's: (a) including incentives for use of specified technologies; (b) reviewing the AO technical evaluation process to better understand and mitigate any bias against collaboration between Centers in favor of proposals that bid all technical capabilities at the proposing Center; (c) identifying core capabilities (or facilities) that can be included in upcoming AO's as an expansion of the mandatory capabilities such as currently designated with the use of the deep space network; and, (d) establishing guidelines, by AO for mission class, to designate appropriate Center proposal leadership, and inter-Center collaboration arrangements.

AGENCY INTEGRATION

The Agency Integration (AI) team, positioned in the Administrator's Office, seeks to inform and coordinate strategy and implementation planning across several key areas. The team also ensures a consistent operating picture by tracking changes in the external environment, engaging with external stakeholders, identifying opportunities, and aligning objectives to Agency mission areas. AI also develops Level Zero/One guidance for implementing organizations, conducts external assessments, and helps communicate the Agency's core purpose and mission. Most recently, Agency Integration organized Strategic Implementation Planning sessions on the following topics: low-Earth orbit commercialization, the next phase of the International Space Station (ISS), characterizing the strategy for cis-lunar space, planning for Mars precursor missions, and, the development of the Agency's integrated Low Earth Orbit and Mars strategy.

NASA WORKFORCE

Reflective of NASA's strong mission, project focus, and annual results from the Federal Employee Viewpoint Survey (FEVS), NASA is proud to have been named by the Partnership for Public Service as the "Best Place to Work" in the Federal Government (among Large Agencies) since 2012. The Agency has developed a positive work culture with a high level of employee engagement through deliberate, proactive initiatives over time. This accomplishment is based on NASA's Workforce Culture Strategy, which flows through all our workforce initiatives. Key focus areas include connecting employees, building model supervisors, and recognizing and rewarding innovative performance. Through these investments, NASA employees are heavily engaged in their work and consistently cite shared values, shared commitment to the mission, and loyalty to the Agency as reasons for engagement. This fuels a deep feeling of community at NASA, commonly referred to as "the NASA Family."

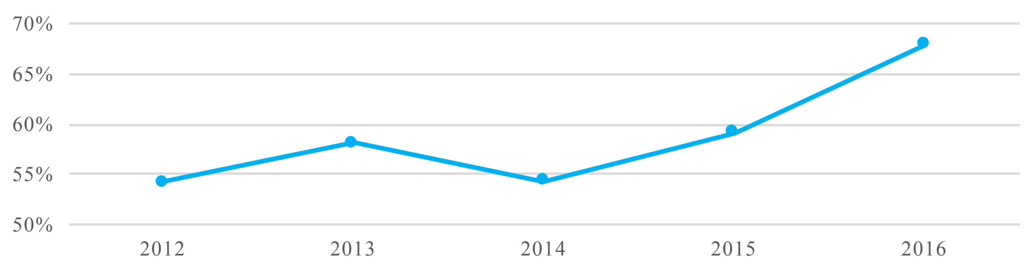


Figure 5.1 FEVS Response Rates Trends

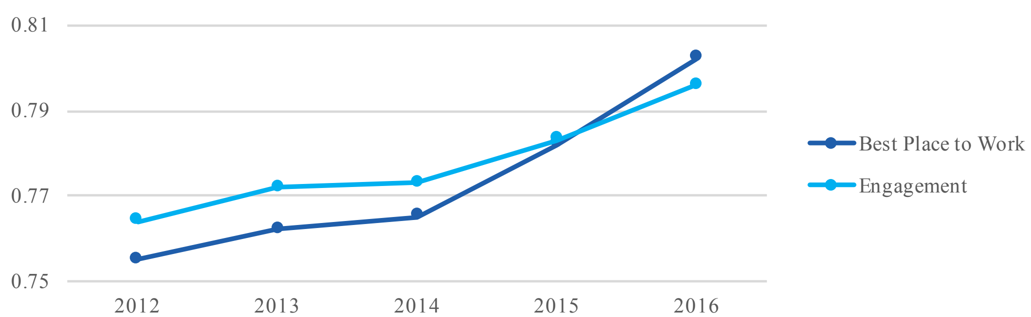


Figure 5.2 Trends in Select FEVS Responses

NASA's workforce strategy is driven primarily by two critical components for success: a deep understanding of long-term budget planning and a strong need to recruit extraordinary workers for highly competitive positions in science, technology, engineering, and mathematics. Additional drivers to NASA's strategic workforce planning include:

- **Operating in a "full-cost accounting" environment:** In Fiscal Year 2004 (FY04), NASA switched to a model of full-cost accounting, which ties all Agency costs (including labor costs) to specific programs and projects. Full-cost accounting supports workforce transparency in two ways: first, it allows NASA to track all employees tied to a specific project and determine the total number of labor hours utilized per project. Second, it allows the Agency to calculate how much time each individual employee has spent working on a particular program or project.

- **Shift in mission to science and technology:** In 2010, the President and Congress unveiled an ambitious new direction for NASA, laying the groundwork for a sustainable program of exploration and innovation. As a result of this change in priorities, the Agency recognized the need to assess and manage risks associated with workforce transitions, particularly in light of the lead time required to shape workforce composition in government organizations.

- **Requirement to manage to a full-time equivalent (FTE) "ceiling":** The adherence to existing ceiling levels is monitored and measured by the Agency on an ongoing basis.

Since FY10, the gap between the size of the contractor workforce (WYE) and the civil service workforce (FTE) has decreased. As of FY15, for every one civil servant, there were roughly two contractors from various private sector employers who supported NASA.

From the beginning of FY06 to the current year-to-date, the median age of a civil servant working at NASA has increased from approximately 46 to 51 years old.

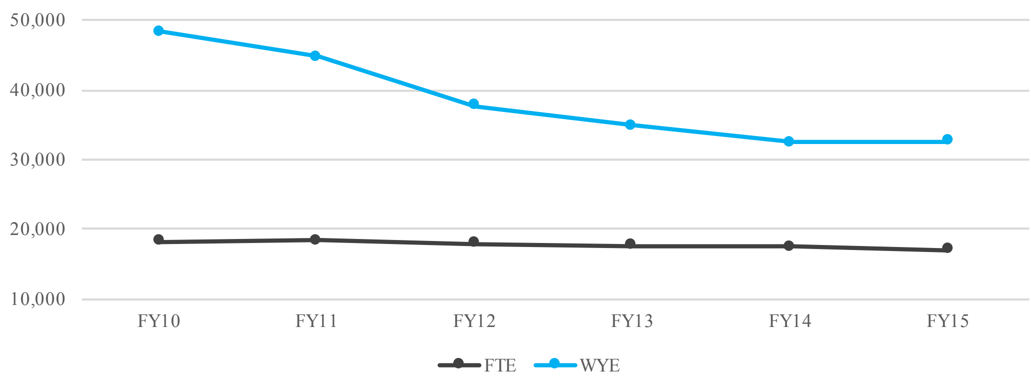


Figure 5.3 Civil Service and Contractor Workforce Trends

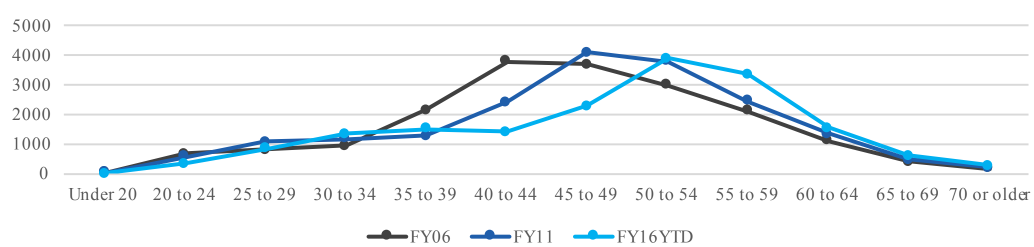


Figure 5.4 Age Distribution of Civil Service Workforce

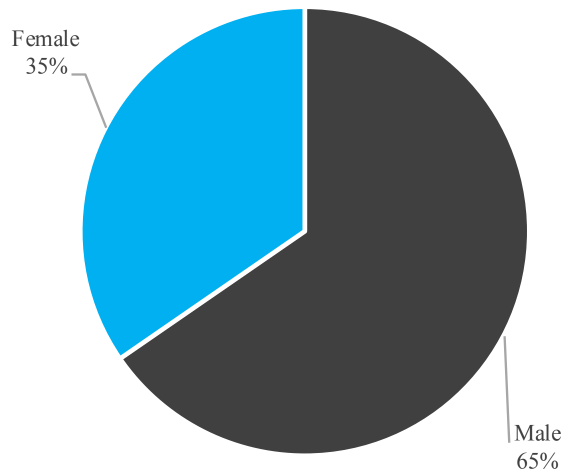


Figure 5.5 Workforce by Gender

Today, women make up over one-third of the workforce.

NASA takes great pride in highlighting our employees and their diversity. Today, individuals identified as African American make up the second largest racial demographic. Additionally, a significant number of African Americans (1000+), Hispanics or Latinos (400+), and Asians or Pacific Islanders (200+) in the civil service actively support NASA's business related fields on a day-to-day basis.

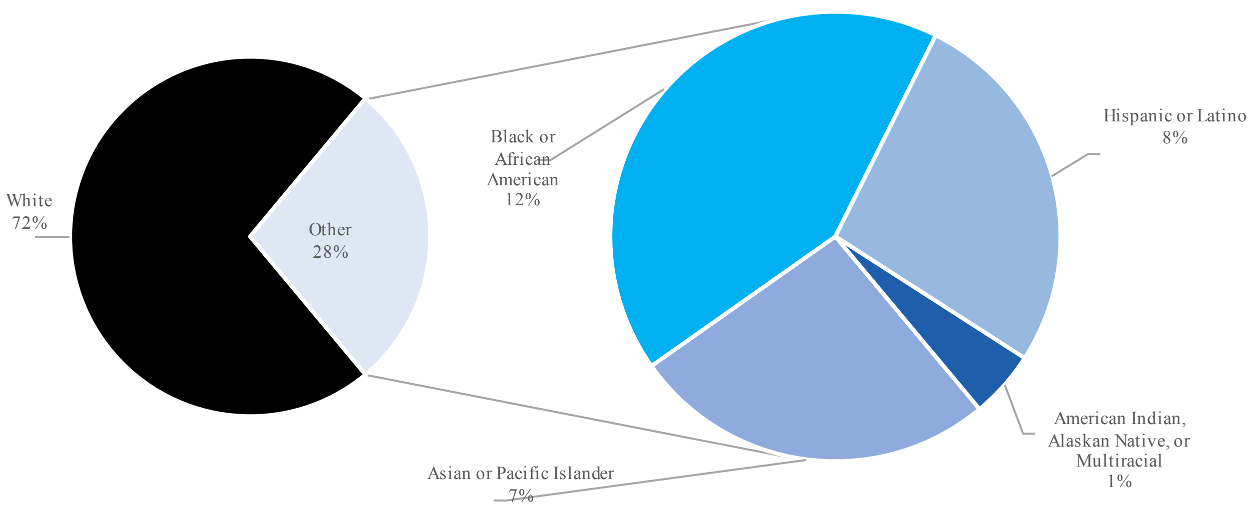


Figure 5.6 Workforce by Diversity

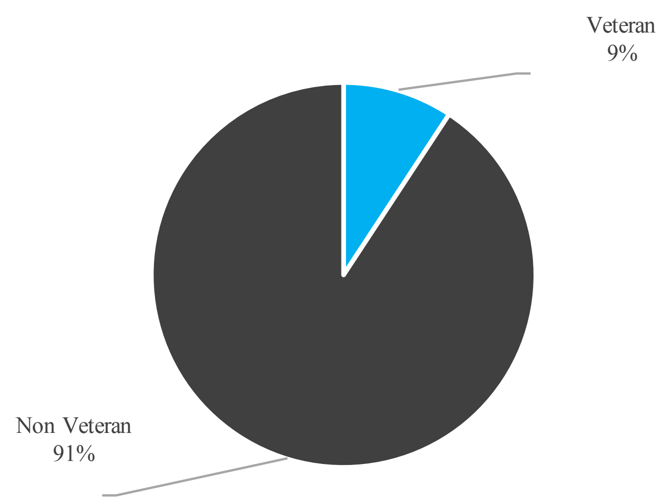


Figure 5.7 Workforce by Veterans

Veterans compose nine percent of NASA's workforce. In addition, a large number of veterans hold professional engineering positions (43%).

Over half of the civil servant population has served between ten and thirty years of Federal service at NASA. Of this group, over 5,700 employees are working in engineering-related fields (e.g. Aeronautic Research and Space Flight Operations) and another 2,500 employees are working in business-related fields.

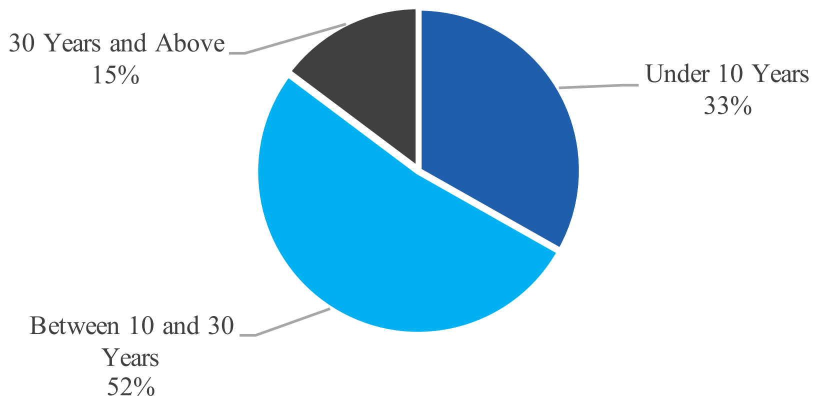


Figure 5.8 Length of Service at NASA

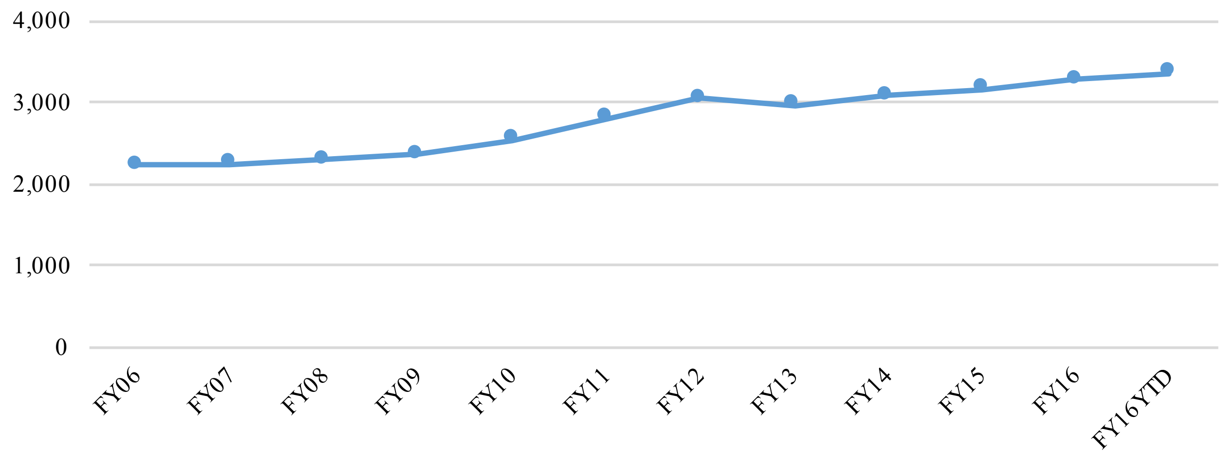


Figure 5.9 Retirement Eligibility Over Time

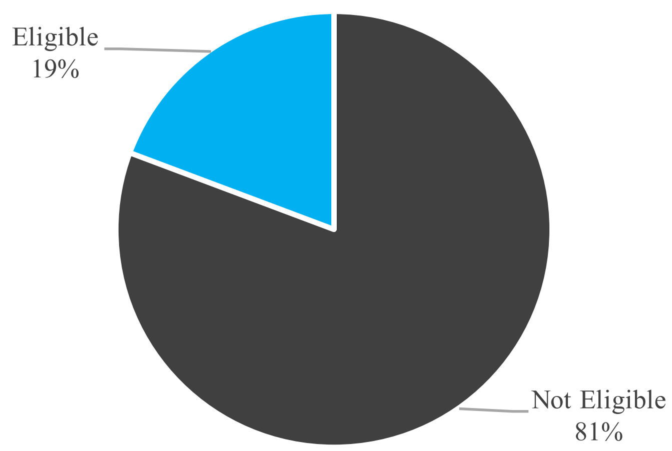


Figure 5.10 Retirement Eligibility of Current Workforce

NASA employees believe in the importance of their work, which in turn motivates many to continue working beyond their retirement eligibility date. In fact, the number of retirement eligible employees has increased by more than 1,100 since FY06. Please note that this data represents the beginning of each fiscal year and the current year-to-date.

While NASA is committed to creating an environment where employees feel engaged, motivated and inspired to create innovative ideas, the Agency is also dedicated to ensuring that it has the best and brightest minds from across the United States. We are actively exploring creative ways to seek out and hire the next generation of NASA employees because almost one-fifth of the workforce is retirement eligible.

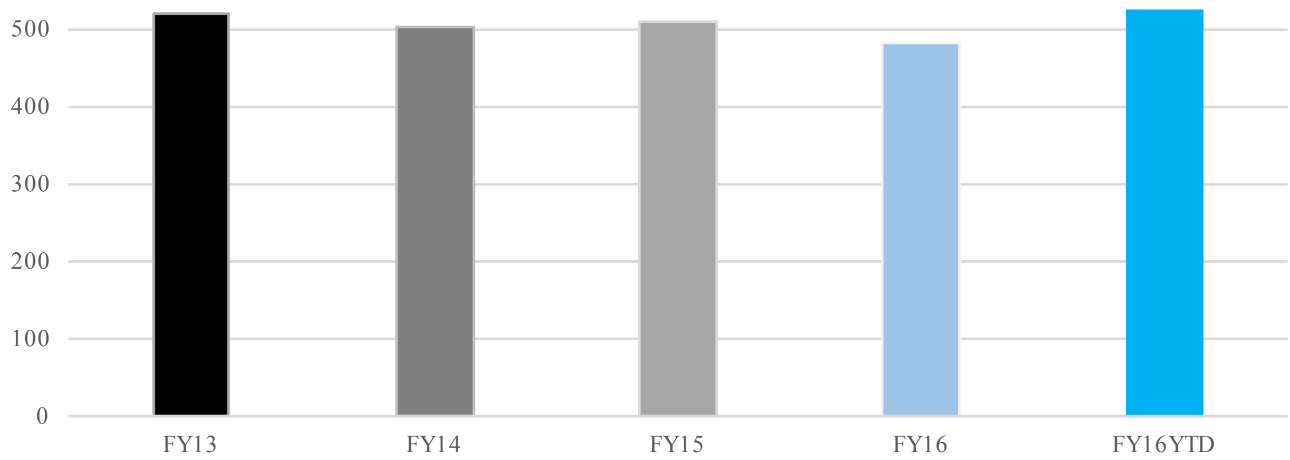


Figure 5.11 NASA Students Over Time

Despite making up less than three present of the total workforce, approximately 500 students onboard each fiscal year since the implementation of the Pathways Program in FY13. This program provides training and development opportunities for students and recent graduates interested in pursuing careers in the Federal service. Please note that the data represents the beginning of each fiscal year and the current year-to-date.

Today, the majority of civil servants working at NASA have positions that are GS 12 and above. Through competitive salaries, open collaboration and a positive work culture, the Agency strives to preserve its employees' technical skills and knowledge, which are highly sought-after by private sector companies.

Since FY12, NASA has hired or converted almost 1,300 employees for positions at GS 11 and below. We are actively promoting our employer brand and refining our recruitment efforts in order to encourage more extraordinary individuals to apply for future career opportunities at NASA.

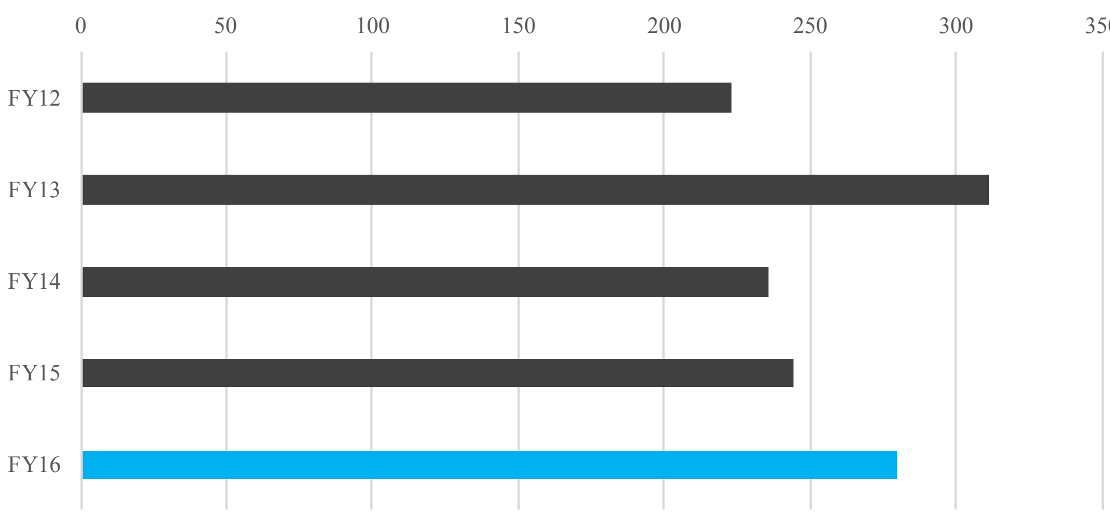


Figure 5.12 Hires and Conversions of GS11 and Below Employees

NASA recognizes that part of being a great place to work includes the ongoing responsibility to address employee misconduct and poor performance when it occurs. This is accomplished in part through the employee relations (ER) program. Each NASA Center administers its own ER program as part of its human resources (HR) operations. The HR Specialists who lead the Center ER program serve as advisors to Center management by providing technical advice and guidance on a wide range of workplace issues, to include those issues that result in disciplinary, adverse and performance-based personnel actions. In addition, the Office of Human Capital Management (OHCM) provides ER policy oversight and guidance for the Centers' ER programs and coordinates agency-wide activities for the entire ER community. OHCM also serves as a liaison with the Office of Personnel Management (OPM) and other federal agencies for related matters affecting NASA's workforce.

NASA has two Labor Unions, the International Federation of Professional and Technical Engineers (IFPTE) and the American Federation of Government Employees (AFGE).

Collectively, these two Unions represent 53% of the workforce and all of NASA's Centers, except Armstrong Flight Research Center (AFRC) and Stennis Space Center (SSC). AFRC and SSC employees are not covered under a bargaining unit because they have not filed a petition with the Federal Labor Relations Authority (FLRA) to request labor representation.

At the Agency level, NASA is responsible for informing these Unions of changes to Agency policies/programs that impact bargaining unit employees. At the Center level, Collective Bargaining Agreements exist between Management and the Union.

Additionally, the Agency Labor Management Forum (LMF) was formed as a result of Executive Order (EO) 13522, creating Labor-Management Forums To Improve Delivery of Government Services. The Agency LMF meets approximately every other month and consists of 14 members, seven from NASA Management and seven from NASA's two Labor unions, IFPTE and AFGE. The Agency LMF's co-chairs, NASA Associate Administrator Robert Lightfoot and Labor President of Local 30 (Ames Research Center) Lee Stone, determine the topics (typically 1-2 for each for management and labor).

The EO also required LMFs to be established at each Center with employees represented by Labor. Further, the EO prescribes that Management allow Labor to have pre-decisional involvement (PDI) in topics that impact employees, regardless of whether or not those topics are ones in which Labor would traditionally have input.

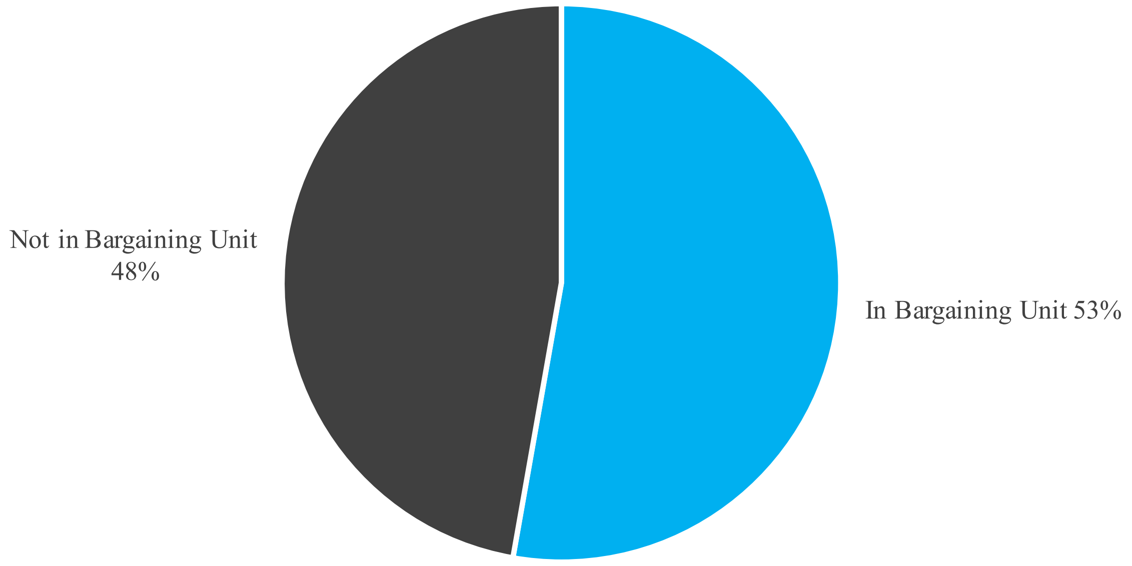


Figure 5.13 Workforce by Bargaining Unit Status

NASA BUDGET OVERVIEW

NASA's budget formulation is one of the Agency's central processes. The development of NASA's budget plan and the application of budget authority to achieve the Agency's objectives is carried out through a four stage Planning, Programming, Budgeting, and Execution process, referred to as PPBE. The PPBE process integrates and formalizes what will and will not be done by the Agency for a given time period. Requirements for budget formulation are included in NASA Procedural Requirements (NPR) 9420.1A.

PLANNING

The continuous process of assessment and adjustment of NASA's goals and objectives.

PROGRAMMING

A bottom-up process to gather data and raise issues regarding the resources necessary to accomplish the mission, with prioritization decisions.

BUDGETING

The process of aligning resources against priorities and presenting Agency decisions to the White House Office of Management and Budget (OMB) in the OMB Submit. OMB assesses the submission in the context of overall Administration policy and the requirements of other agencies, and then responds to NASA (in a document called "passback") with OMB's adjustments to the Agency's submission. After a period of negotiations in which NASA and OMB come to agreement on a final Administration position, NASA publishes its Agency Congressional Justification and advocates on behalf of the President's Budget Request.

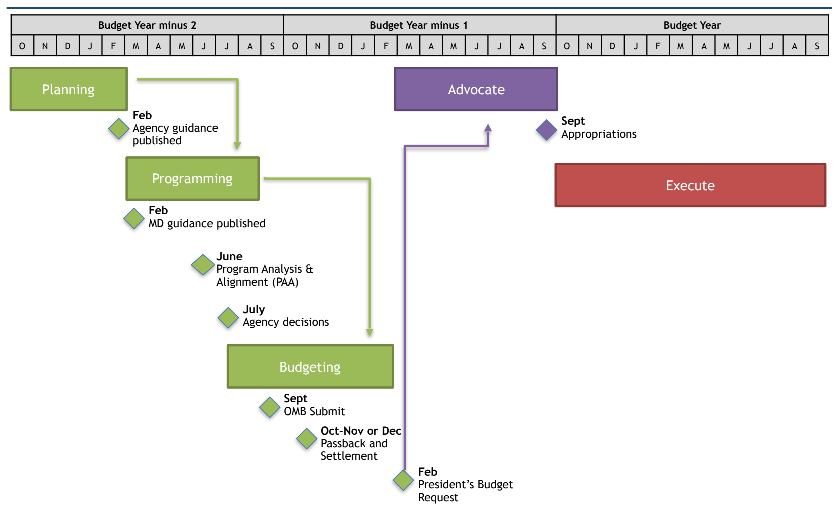


Figure 6.1 PPBE: Example

EXECUTION

The process of spending, recording, monitoring, and controlling budget authority to conduct NASA's work once funds have been appropriated. This includes establishing, adjusting, and gaining the approval of the Appropriations Committees on the Agency's operating plans.

ADDITIONAL RESOURCES

NASA NPR 9420.1A BUDGET FORMULATION - *http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPR&c=9420&s=1A*

NASA NPR 9470.1 BUDGET EXECUTION - *http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPR&c=9470&s=1*

NASA BUDGET OVERVIEW

NASA typically deals with four budget cycles at any one time. Figure 6.2 illustrates the current status of NASA's PPBE cycle for FY15 – FY19, demonstrating how multiple budgets are in play at any given time, at varying levels of maturity in the PPBE process. The FY15 budget received a clean audit (NASA's 5th clean audit in a row) and is mostly complete with some remaining funds to be outlaid. NASA has started the annual audit of the FY16 budget and has mostly completed obligations (most funds have 2 years to be fully obligated). NASA's FY17 President's Budget Request was released in February 2016. NASA expects to be under a continuing resolution for at least the first three months of FY17 until the Congress enacts FY17 appropriations. See Section 6 Congressional Relations for a recent history of appropriations and continuing resolutions. NASA's FY18 Budget is still in development. NASA anticipates the new Administration to submit the FY18 Budget to the Congress in the March through May 2017 timeframe, per guidance from OMB (rather than the typical February submission in non-election years). The development of NASA's FY19 budget will be compressed more than normal during the summer of calendar year 2017 pending release of the FY18 request by the new Administration.

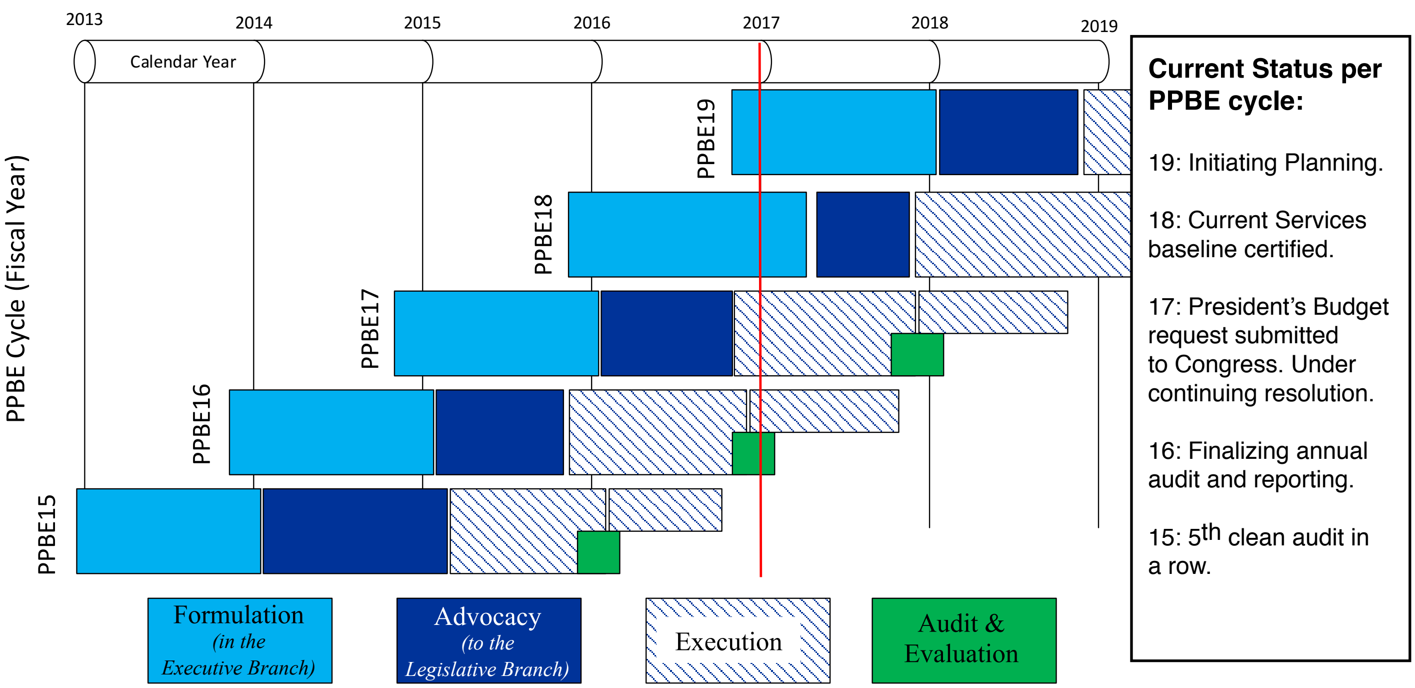


Figure 6.2 PPBE Budget Cycles

NASA BUDGET OVERVIEW

The current status and forthcoming dates for the FY18 and FY19 budgets are summarized in Figure 6.3. NASA is using Current Services levels to plan for FY18 through FY22, per guidance from OMB. Current Services levels are determined by escalating the current enacted budget (FY16) for the out-years based on inflation indices provided by OMB. Following the inauguration, there is a short window of time during which the new Administration will provide guidance to agencies that will shape the FY18 budget request, and guide planning and priorities for the FY19 budget formulation process. This guidance coincides with the development of NASA's 2018 Strategic Plan (see Section 5), and the budget guidance provided will be very influential in the strategic planning process.

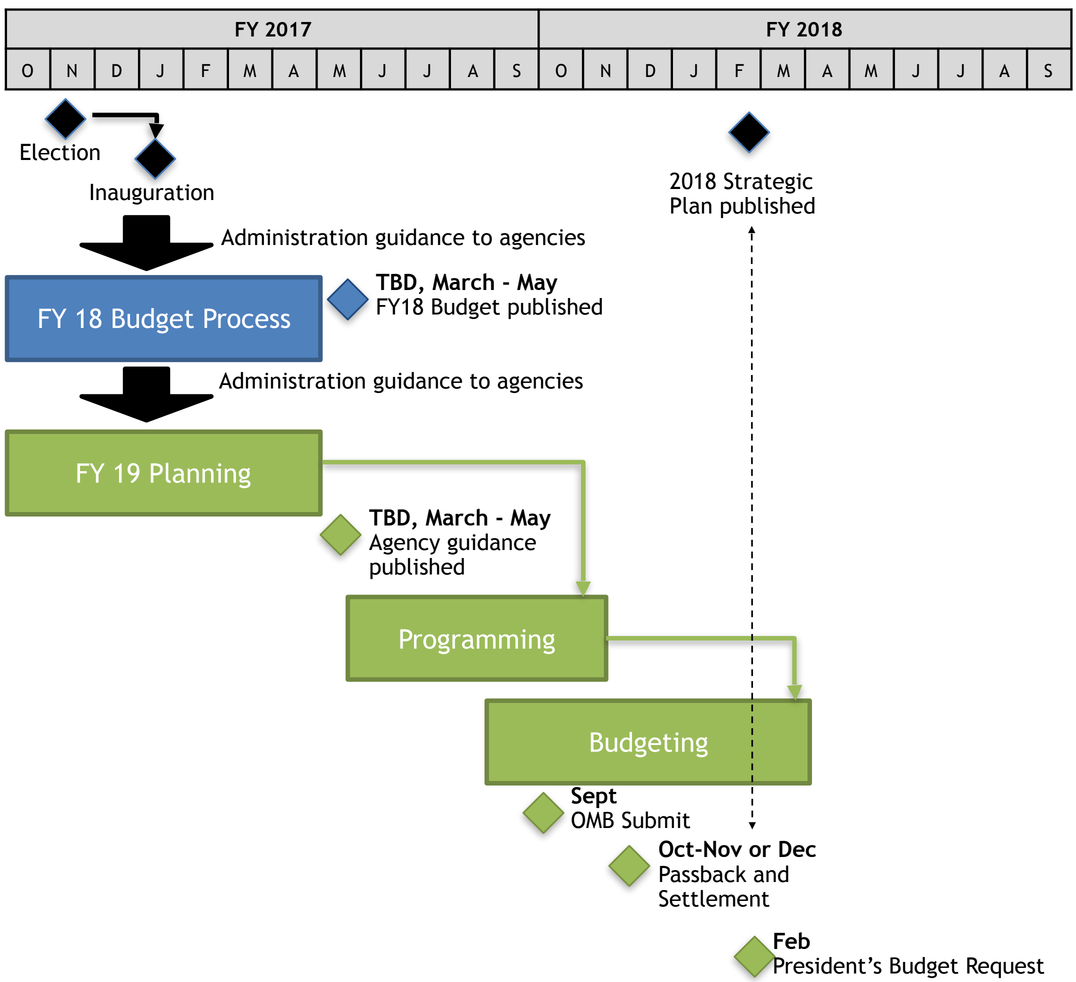


Figure 6.3 Current Status and Forthcoming Dates for the FY18 and FY19 Budgets

NASA BUDGET OVERVIEW

RECENT BUDGET HISTORY

The Government's overall fiscal condition affects NASA's budget. The President's FY 2011 Budget – released just as the full impact of the recent recession was being realized – projected that NASA's budget would exceed $20 billion by 2014. The FY 2014 Budget – released just after the sequester order in FY 2013 – held NASA flat at $17.8 billion throughout the runout, $2.2 billion shy of the total estimated in the FY 2011 Budget. FY 2016 appropriations were the first to approach the FY 2011 budget levels, and the Current Services runout shows comparable projected growth.

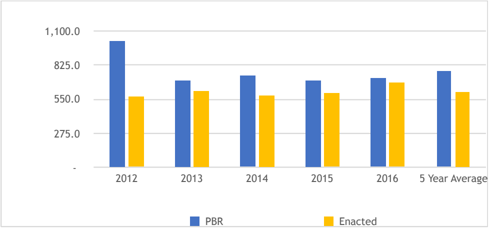


Figure 6.4 Space Technology Budget History

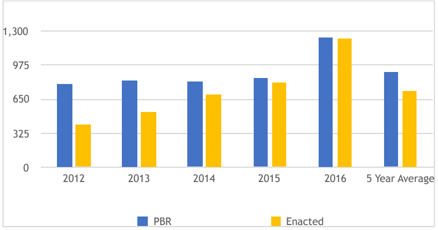


Figure 6.5 Commercial Crew Budget History

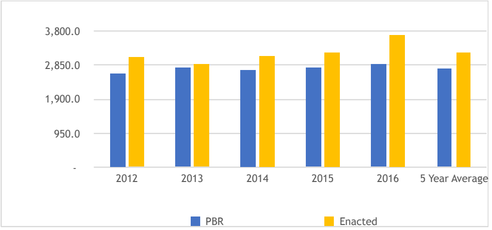


Figure 6.6 Exploration Systems Development Budget History

In recent years, there have been disconnects between the Administration budget request and the Congressional appropriations in Exploration Systems as illustrated above. In addition, internal to the Science and Space Technology portfolio there have been disconnects, where certain Congressionally-favored projects received specific appropriations (or guidance in report language) well in excess of what the Administration requested – most notably the Europa, WFIRST, and RESTORE-L projects. In addition to specified appropriations, the legislation also included requirements for specific launch dates (by year).

There has also been significant fiscal pressure placed on the Agency's facilities and management offices. Much of NASA's physical plant was built in the Apollo and Shuttle eras, and is well past its design life. Despite wide recognition of this situation, the pressure of trying to accommodate the competing programmatic priorities has led to a disproportionate impact on the Agency's institution. The Administration's request for the Safety, Security, and Mission Services account, which includes all Agency and Center Management, including facilities maintenance, dropped nearly ten percent from FY 12 to FY 13, and has yet to recover. Even more, appropriations have consistently lagged the requests, compounding the problem. There have been similar decreases in Institutional Construction of Facilities budgets.

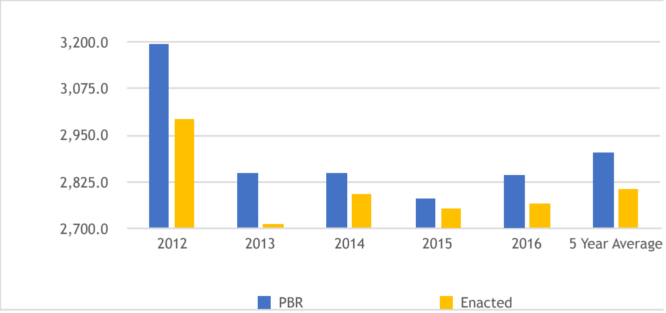


Figure 6.7 Safety, Security, and Mission Services Budget History

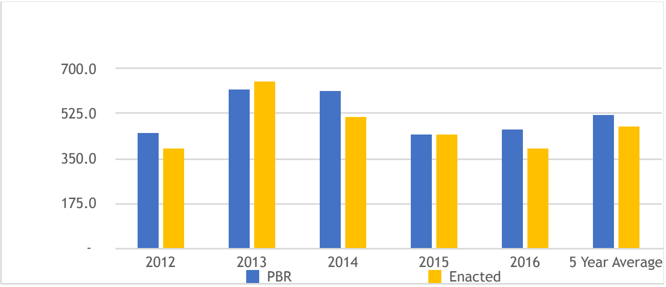


Figure 6.8 Construction and Environmental Compliance and Restoration Budget History

NASA has embarked on a series of ambitious reforms of its business processes to increase the efficiency of business and management operations, but maintaining the Safety, Security, and Mission Services (SSMS) and Construction and Environmental Compliance and Restoration (CECR) budgets at these levels may be unsustainable in the middle- to long-term, without impacting the missions. NASA has also steadily reduced its headcount during this period, continuing reductions from a peak of ~36,000 during the Apollo Program.

OTHER FUNDING SOURCES

NASA has authority to perform work on behalf of other entities on a reimbursable basis, receiving funds in addition to those appropriated directly for NASA. The primary example of this authority is NASA's work as the acquisition agent for the National Oceanic and Atmospheric Administration's (NOAA's) weather satellites. See Figure 6.9 for a summary of the annual reimbursable funding executed by NASA. NASA also partners extensively using non-reimbursable agreements.

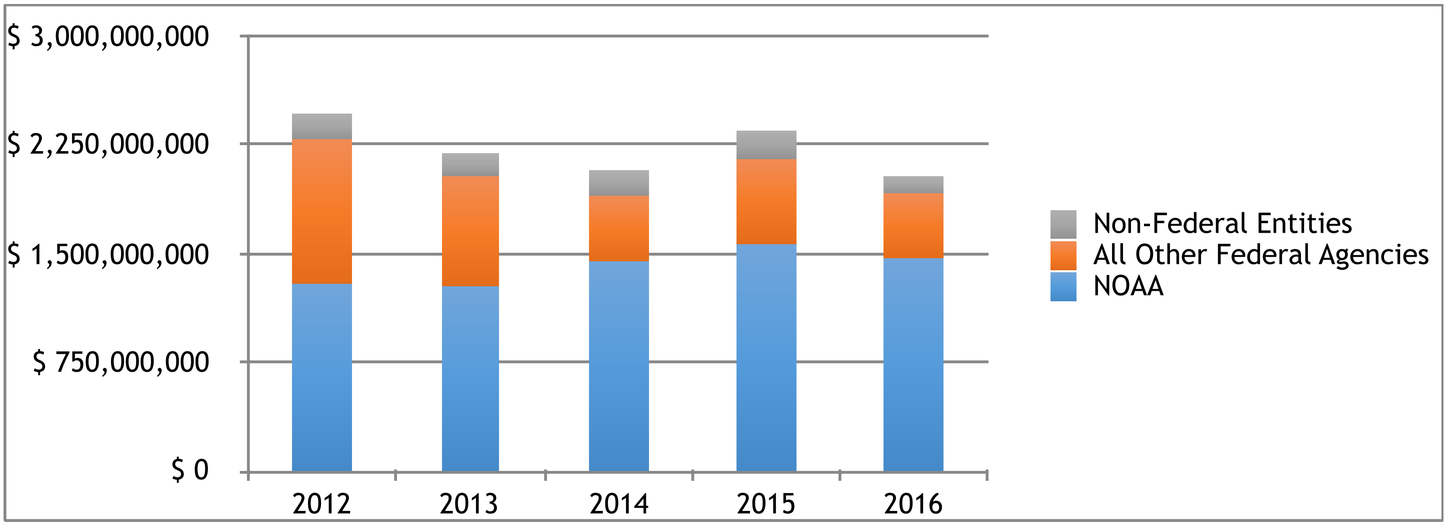


Figure 6.9 Summary of Annual Reimbursable Funding

NASA STRATEGIC PLAN

NASA STRATEGIC PLAN

STRATEGIC FRAMEWORK

NASA's Strategic Plan defines the Agency's mission, long-term goals, strategies planned, and the approaches it will use to monitor its progress in addressing specific national problems, needs, challenges, and opportunities related to its mission. It reflects the laws and policies relevant to the Agency, such as the National Aeronautics and Space Act, the 2010 U.S. National Space Policy, the NASA Authorization Act of 2010, and other Administration priorities.

NASA is currently operating under the 2014 Strategic Plan, which was issued on February 4, 2014. Agencies are required to update their strategic plans on a four-year cycle during the first full year of any new Presidential term. The 2018 Strategic Plan, which covers the period of FY2018-FY2022, will be released on February 5, 2018, concurrent with the FY2019 President's Budget Request.

STRATEGIC ALIGNMENT

NASA's Strategic Plan has been crafted to provide a direct link between the work of every single employee to at least one of NASA's Strategic Goals and Strategic Objectives. This is done by intentionally aligning each program identified in the budget to a single Strategic Objective. The plan also establishes the framework against which the Agency will assess the progress it is making towards meeting its goals and objectives on several different time horizons.

ADDITIONAL RESOURCES

NATIONAL AERONAUTICS AND SPACE ACT - *https://www.gpo.gov/fdsys/pkg/USCODE-2014-title51/pdf/USCODE-2014-title51-subtitleII.pdf*

2010 U.S. NATIONAL SPACE POLICY - *https://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf*

NASA 2010 AUTHORIZATION ACT - *http://www.nasa.gov/pdf/649377main_PL_111-267.pdf*

NASA 2014 STRATEGIC PLAN - *https://www.nasa.gov/sites/default/files/files/FY2014_NASA_SP_508c.pdf*

GOVERNMENT PERFORMANCE AND RESULTS ACT MODERNIZATION ACT (GPRAMA), 2010 - *https://www.gpo.gov/fdsys/pkg/BILLS-111hr2142enr/pdf/BILLS-111hr2142enr.pdf*

OFFICE OF MANAGEMENT AND BUDGET CIRCULAR A-11 - *https://www.whitehouse.gov/omb/circulars_a11_current_year_a11_toc*

STRATEGIC PLAN

STRATEGIC GOAL 1

Expand the frontiers of knowledge, capability, and opportunity in space

By empowering the NASA community to...

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.

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.

Objective 1.3: Facilitate and utilize U.S. commercial capabilities to deliver cargo and crew to space.

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

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

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

Objective 1.7: Transform NASA missions and advance the Nation's capabilities by maturing crosscutting and innovative space technologies.

STRATEGIC GOAL 2

Advance understanding of Earth and develop technologies to improve the quality of life on our home planet

By engaging our workforce and partners to...

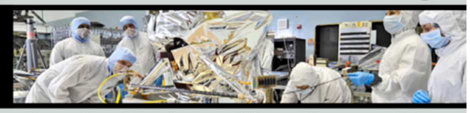
Objective 2.1: Enable a revolutionary transformation for safe and sustainable U.S. and global aviation by advancing aeronautics research.

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

Objective 2.3: Optimize Agency technology investments, foster open innovation, and facilitate technology infusion, ensuring the greatest national benefit.

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.

STRATEGIC GOAL 3



Serve the American public and accomplish our Mission by effectively managing our people, technical capabilities, and infrastructure

By working together to...

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.

Objective 3.2: Ensure the availability and continued advance of strategic technical programmatic capabilities to sustain NASA's Mission.

Objective 3.3: Provide secure, effective, and affordable information technologies and services that enable NASA's Mission.

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

Figure 7.1 NASA's Strategic Framework, as Defined in the 2014 Strategic Plan

PERFORMANCE SUMMARY

On an annual basis, NASA is required to develop an annual performance plan (APP), including the multiyear performance goals and annual performance indicators that the Agency will report on to demonstrate that it is making measurable progress towards the Strategic Objectives outlined in the Strategic Plan. The plan is published on the first Monday in February, along with the President's Budget Request. NASA is also required to report performance publically twice per year. Preliminary, summary performance data are released in the Agency Financial Report (AFR), which comes out about six weeks after the end of the fiscal year. Final, detailed performance data are released in the Annual Performance Report (APR), which typically comes out on the first Monday in February, along with the President's Budget Request.

Unlike most other federal agencies, NASA follows an "alternative form," or milestone-based, approach for most of its performance measures since those are more applicable to an R&D agency. NASA's performance measures typically include key milestones and reviews in the formulation, development, and operation of its missions, and are often items on the critical path. NASA has met or exceeded 83% of our performance targets in 2016, based on preliminary year-end data.

All Performance Metrics

Number of Performance Metrics		193	
Green	Yellow	Red	Red/White
83%	10%	6%	1%
160	19	13	1

Performance Metrics by Strategic Goal

Strategic Goal 1				Strategic Goal 2			Strategic Goal 3		
82				50			61		
Green	Yellow	Red	Red/ White	Green	Yellow	Red	Green	Yellow	Red
83%	11%	5%	1%	84%	8%	8%	82%	10%	8%
68	9	4	1	42	4	4	50	6	5

Green: On Track or Complete
Yellow: Slightly Below Target and/or Behind Schedule
Red: Significantly Below Target and/or Behind Schedule
White: Cancelled or Postponed

Figure 7.2 Perfomance Summary for FY16

CONGRESSIONAL RELATIONS

HOME

CONGRESSIONAL RELATIONS

NASA has been the beneficiary of broad, bipartisan Congressional support since its establishment in 1958. While NASA authorization legislation is not enacted on an annual basis, such authorization legislation typically sets out policy that reflects broad consensus, most recently with the NASA Authorization Act of 2010, which established a guideline for human space exploration, science, aeronautics, and technology. During the period since enactment of the NASA Authorization Act of 2010, annual appropriations have been generally aligned to the guideline set in that legislation, with recent NASA funding levels in excess of the President's request. NASA supporters in Congress are often part of delegations representing states in which NASA's nine Centers are located, while authorization and appropriations Chairmen and Ranking Members often assume roles of national leaders for investment in NASA space and aeronautics. There are four primary Congressional Committees that oversee NASA—the House Committee on Science, Space, and Technology; the Senate Committee on Commerce, Science, and Transportation; and the House and Senate Committees on Appropriations—which are summarized in the following subsections.

APPROPRIATIONS COMMITTEES

NASA is subject to oversight by several Senate and House Committees. This section lists the Congressional Committees with responsibility for appropriation of NASA funding. The list is followed by a description of the Committees on Appropriations, their jurisdiction, and their respective Subcommittees with primary responsibility for NASA.

UNITED STATES HOUSE OF REPRESENTATIVES	UNITED STATES SENATE
Committee on Appropriations U.S. House of Representatives	**Committee on Appropriations U.S. Senate**
Chairman: Harold Rogers (R-KY)*	Chairman: Thad Cochran (R-MS)
Ranking Member: Nita Lowey (D-NY)	Ranking Member: Barbara A. Mikulski (D-MD)**
Subcommittee on Commerce, Justice, Science, and Related Agencies	**Subcommittee on Commerce, Justice, Science, and Related Agencies**
Chairman: John Culberson (R-TX)	Chairman: Richard Shelby (R-AL)
Acting Ranking Member: Michael M. Honda (D-CA)	Ranking Member: Barbara A. Mikulski (D-MD)**

**Member rotating of Chairmanship at end of 114th Congress due to Republican Conference rules*
***Member retiring at end of 114th Congress*

Table 8.1 Appropriations Committees and Leadership

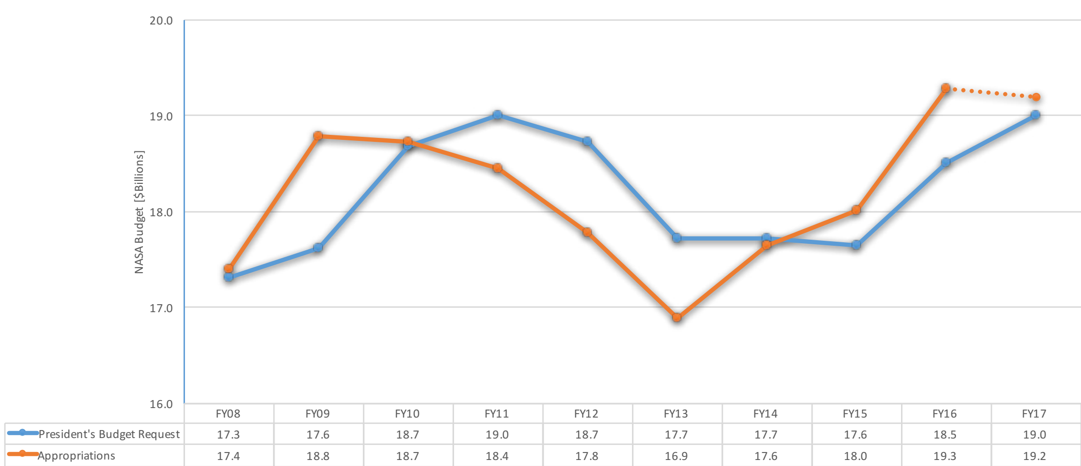
The House and Senate Committees on Appropriations are responsible for writing annual bills that allocate discretionary Treasury funds for operations and activities of federal agencies, and under Article 1 of the Constitution, appropriations measures are to originate in the House of Representatives. All discretionary programs in the Federal government require an appropriation every year. The Committees on Appropriations work on regular appropriations bills that must be signed into law by October 1, the start of the fiscal year, to fund the operations of the Federal government. When appropriations bills are not passed by the start of the fiscal year, the Appropriations Committees of both chambers produce a Continuing Resolution (CR). A CR is legislation that prevents agencies from shutting down by keeping them running at the previous year's funding level when appropriations bills are not passed by fiscal year start. When Subcommittee bills do not individually proceed to enactment, omnibus appropriation bills that incorporate multiple Subcommittee bills may be enacted. On some occasions, year-long CRs are enacted. A summary of recent annual appropriation outcomes is provided in the table below.

FISCAL YEAR	REGULAR APPROPRIATION ENACTMENT	OMNIBUS APPROPRIATION ENACTMENT	YEAR-LONG CONTINUING RESOLUTION ENACTMENT	NUMBER OF CONTINUING RESOLUTIONS	GOVERNMENT SHUTDOWN
FY 2017	No	TBD	TBD	1*	TBD
FY 2016	No	12/18/15		3	
FY 2015	No	12/16/04		3	
FY 2014	No	1/17/14		2	Oct. 1-17, 2014
FY 2013	No	3/23/13		1	
FY 2012	No	12/23/11		5	
FY 2011	No		4/15/11	8	
FY 2010	No	12/16/09		2	
FY 2009	No		2/13/09	3	
FY 2008	No	12/26/07		4	

**Initial Continuing Resolution (CR) passed through 12/9/16*

Table 8.2 Appropriations Summary

A summary of recent annual appropriations outcomes for NASA, compared with the President's request level, is provided in the figure below:



NOTE: FY17 Appropriations level represents CR level through 12/9/2016 at the FY16 level less 0.496%

Figure 8.1 Recent Annual Appropriations Outcomes vs. President's Request Level

HOUSE COMMITTEE ON APPROPRIATIONS

The House Committee on Appropriations has broad responsibility for appropriating funds for executive branch departments/agencies and the legislative branch. The Rules of the U.S. House of Representatives define the Committee's jurisdiction as "appropriation of the revenue for the support of the Government" (and related powers to rescind and transfer funds). The Committee's 12 Subcommittees are aligned with responsibility for specific departments and agencies. The House Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies has jurisdiction over NASA.

HOUSE APPROPRIATIONS SUBCOMMITTEE ON COMMERCE, JUSTICE, SCIENCE, AND RELATED AGENCIES/ JURISDICTION

The House Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies (CJS) provides funding for the Department of Commerce, the Department of Justice, the Office of Science and Technology Policy, NASA, the National Science Foundation, and several related commissions and agencies. The annual CJS Appropriations Bill is one of the larger domestic appropriations bills, totaling $56 billion in FY 2016. NASA funding has averaged approximately 35 percent of the CJS bill over the last three years.

The CJS Subcommittee reviews the President's budget request for each department/agency, and hears department/agency officials' testimony. Typically, the Subcommittee holds one hearing per year on the respective department/agency budget request, and Subcommittee staff engage in detailed review of the request through multiple briefings by department/agency officials. The Subcommittee drafts annual appropriations bills that include funding for each department/agency under its jurisdiction. When an annual appropriations bill has been enacted, departments/agencies are required to submit "spend plans," pursuant to statutory direction, to the House and Senate Committees on Appropriations, to reflect the manner in which the department/agency is executing the appropriation, including proposed reprogrammings, which require Committee concurrence. As necessary, the Subcommittees drafts supplemental appropriations bills for emergency expenses during a fiscal year.

SENATE COMMITTEE ON APPROPRIATIONS

The Senate Committee on Appropriations, like its House counterpart, is responsible for writing annual bills that allocate Treasury funds for operations and activities of Federal agencies, and has 12 Subcommittees, aligned with the House, with responsibility for executive branch agencies and the legislative branch. The Senate Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies has jurisdiction over NASA.

SENATE APPROPRIATIONS SUBCOMMITTEE ON COMMERCE, JUSTICE, SCIENCE, AND RELATED AGENCIES/ JURISDICTION

The Senate Appropriations CJS Subcommittee has a jurisdiction that mirrors the House Appropriations CJS Subcommittee. The Subcommittee reviews the President's budget request for each department/agency, hears agency officials' testimony, and drafts agency on Commerce, Justice, Science, and Related Agencies (CJS) provides funding for the Department of Commerce, the Department of Justice, the Office of Science and Technology Policy, NASA, the National Science Foundation, and several related commissions and agencies. The annual CJS Appropriations Bill is one of the larger domestic appropriations bills, totaling $56 billion in FY 2016. NASA funding has averaged approximately 35 percent of the CJS bill over the last three years.

The CJS Subcommittee reviews the President's budget request for each department/agency, and hears department/agency officials' testimony. Typically, the Subcommittee holds one hearing per year on the respective department/agency budget request, and Subcommittee staff engage in detailed review of the request through multiple briefings by department/agency officials. The Subcommittee drafts annual appropriations bills that include funding for each department/agency under its jurisdiction. When an annual appropriations bill has been enacted, departments/agencies are required to submit "spend plans," pursuant to statutory direction, to the House and Senate Committees on Appropriations, to reflect the manner in which the department/agency is executing the appropriation, including proposed reprogrammings, which require Committee concurrence. As necessary, the Subcommittees drafts supplemental appropriations bills for emergency expenses during a fiscal year.

AUTHORIZATION COMMITTEES

NASA AUTHORIZATION COMMITTEES AND LEADERSHIP		
	UNITED STATES HOUSE OF REPRESENTATIVES	**UNITED STATES SENATE**
Authorization Committees	**Committee on Science, Space, and Technology**	**Committee on Commerce, Science, and Transportation**
	Chairman: Lamar Smith (R-TX)	Chairman: John Thune (R-SD)
	Ranking Member: Eddie Bernice Johnson (D-TX)	Ranking Member: Bill Nelson (D-FL)
	Subcommittee on Space	**Subcommittee on Space, Science, and Competitiveness**
	Chairman: Brian Babin (R-TX)	Chairman: Ted Cruz (R-TX)
	Ranking Member: Donna Edwards (D-MD)*	Ranking Member: Gary Peters (D-MI)

**Member retiring at end of 114th Congress*

Table 8.3 Authorization Committees and Leadership

The Authorization Committees listed below perform a number of key functions, taking into account the following: Authorization bills establish, continue, or modify federal programs, and are intended to precede the Appropriations process. However, Congress frequently enacts appropriations for a program/agency even though there is no specific authorization for it by waiving rules.

Because the constitution provides that “No money shall be drawn from the treasury, but **in consequence of appropriations made by law,**” an appropriation is required to fund the agency notwithstanding the existence of authorizing legislation. Authorization Committees execute Congressional oversight of agency programs and plans.

Bills often include limits on the amount that can be appropriated for the authorized program/agency as well as specific direction concerning program content that is binding on the agency.

SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

The Committee is composed of six Subcommittees, which together oversee the large range of issues under its jurisdiction. These issues range from communications, highways, aviation, rail, shipping, transportation security, merchant marine, the Coast Guard, oceans, fisheries, climate change, disasters, science, space, interstate commerce, tourism, consumer issues, economic development, technology, competitiveness, product safety, and insurance. The Committee oversees NASA, NSF, NOAA and NIST within the Department of Commerce, and the USCG and considers and confirms presidential appointments.

SUBCOMMITTEE ON SPACE, SCIENCE, AND COMPETITIVENESS

The Senate Subcommittee with oversight jurisdiction over NASA is the Subcommittee on Space, Science, and Competitiveness. The Subcommittee has responsibility for science, technology, engineering, and math (STEM) research and development (R&D) and policy; measurement science and standards; and civil space policy. The Subcommittee conducts oversight on the National Science Foundation, the National Institute of Standards and Technology, the Office of Science and Technology Policy, and the National Technical Information Service. Under the leadership of Chairman Cruz, the Subcommittee has focused heavily on NASA-related issues including a hearing in 2015 on the agency's 2016 budget request and a hearing this year on America's leadership in space. The 2015 hearing featured strong criticism from Chairman Cruz and committee Republicans of a perceived increase in spending on Earth Science missions and research during the Obama Administration. On September 22, 2016, the Subcommittee passed an authorization bill entitled: NASA Transition Authorization Act of 2016. The bill has garnered bipartisan support in the Senate and aims to provide continuity for NASA and its major human exploration programs during the upcoming presidential transition. It is not clear whether the bill will be considered by the full Senate before they adjourn.

HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

The Committee has jurisdiction over most Federal non-defense, scientific R&D, including programs at NASA, Department of Energy, Environmental Protection Agency, National Science Foundation, Federal Aviation Administration, National Oceanic and Atmospheric Administration including the National Weather Service, Federal Emergency Management Administration, U.S. Geological Survey, the National Space Council, and the White House Office of Science and Technology Policy. The Committee's strong interest in how Federal R&D sustains U.S. international competitiveness and economic health dates back to its creation in 1958. Initially centered on space exploration, its jurisdiction now includes civil aviation, energy (including commercial applications), the environment, scientific research, science scholarships, marine research, and standardization of weights and measures through the National Institute of Standards and Technology. The Committee has five Subcommittees.

SUBCOMMITTEE ON SPACE AND AERONAUTICS

The House Subcommittee with oversight jurisdiction over NASA is the Subcommittee on Space and Aeronautics. The Subcommittee has legislative jurisdiction and general oversight and investigative authority on all matters relating to astronautical and aeronautical research and development including: national space policy; exploration, access to, and use of space; sub-orbital access and applications; National Aeronautics and Space Administration and its contractor and government-operated labs; space commercialization; international space cooperation; the National Space Council; space applications, space communications and related matters; Earth remote sensing policy; civil aviation and Federal Aviation Administration research, development, and demonstration; and space law. In 2016, under Chairman Babin, the Subcommittee has held hearings on commercial remote sensing; astronomy, astrophysics, and astrobiology; a review of technology transfer; human spaceflight ethics and obligations; deep space habitats; the commercial space launch industry; the Space Leadership Preservation Act; gravitational waves; and human exploration proposals.

NASA INTERACTION WITH FEDERAL DEPARTMENTS AND AGENCIES

NASA INTERACTION WITH FEDERAL DEPARTMENTS AND AGENCIES

NASA routinely interacts with numerous Federal departments and agencies. The NASA Office of International and Interagency Relations (OIIR) coordinates Agency-level policy interactions with U.S. executive branch departments and agencies, and is the principal Agency liaison with Federal agencies. Interactions between NASA and other Federal departments and agencies occur at multiple levels and across all Centers and Headquarters. In order to provide a strategic perspective on interagency partnerships across the Agency, OIIR leads a monthly Agency-wide forum (the Interagency Partnership Liaison team meeting) and provides monthly reporting to the Office of the Administrator on all active and pending agreements between NASA and other U.S. departments and agencies. As of August 2016, NASA had over 900 active agreements with interagency partners. The majority of these agreements are established at NASA Centers and, unlike international agreements, over 70 percent are reimbursable where the NASA costs associated with the activity are reimbursed by the Federal partner (in full or in part).

DEPARTMENT OF DEFENSE AND INTELLIGENCE COMMUNITY

In coordination with relevant NASA Mission Directorates and Centers, NASA, via OIIR, consults with the Department of Defense (DoD) on a wide variety of program and policy issues and provides the Agency's primary policy point of contact with the Office of the Director of National Intelligence. NASA partnership activities with DoD and the intelligence community include jointly funded and jointly managed programs, reimbursable activities, and information exchanges. For example, NASA partners with the national security community in the areas of: investment in a national space launch base and range capability; certification of new entrant launch vehicles; commercial crew and Orion rescue support; communications; Position, Navigation & Timing; Space Weather and Radiation Monitoring; Near-Earth Object detection, tracking, cataloging, and characterization; rotorcraft; hypersonics; and Uncrewed Aerial Systems, to name a few.

OIIR provides staff support to senior NASA leaders for meetings with DoD and other national security officials, including quarterly Summits among the leaders of NASA, the Air Force, and the National Reconnaissance Office, and also manages the process by which military officers, including astronauts, are assigned to NASA on a reimbursable basis. Through an OIIR Liaison Officer stationed in Colorado Springs, NASA maintains close coordination with the U.S. Air Force Space Command, U.S. Strategic Command and U.S. Northern Command.

As part of the NASA Export Control Program, NASA is among the agencies that review aerospace-related exports and the public release of technical documentation through DoD's Office of Security Review. NASA also consults regularly with the Department's Defense Technology Security Administration on export matters affecting NASA programs.

DEPARTMENT OF COMMERCE

The Commerce Department's Bureau of Industry and Security (BIS) administers the Export Administration Regulations (EAR), which control exports of all dual-use commodities and technologies including the International Space Station (ISS). Accordingly, NASA regularly consults with BIS on dual-use export control matters in support of Agency programs and submits export license applications for transfers of items subject to the EAR. NASA also coordinates with the Commerce Department's National Oceanic and Atmospheric Administration (NOAA) and other Department offices on policy matters regarding remote sensing spacecraft and other issues, such as space commercialization. NASA maintains extensive cooperation with NOAA for Earth science-related missions, as well as space weather and weather satellites, all of which is coordinated primarily through the Science Mission Directorate.

DEPARTMENT OF STATE

NASA consults regularly with the Department of State (DoS) on significant cooperative activities, policy questions, and matters with broader foreign policy implications. These include questions about countries of potential policy concern, export control and non-proliferation issues, and establishing cooperation with international partners. Consistent with U.S. law, NASA coordinates with the DoS before concluding significant international agreements. Interaction occurs at both the staff and leadership levels, including by the NASA Administrator on matters of great importance.

NASA also provides support to the DoS on space matters addressed within the United Nations structure, particularly in the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS). NASA, via OIIR, leads the U.S Government Delegation to the UNCOPUOS Scientific and Technical Subcommittee. In addition, as the regulatory agency charged with administering the International Traffic in Arms Regulations (ITAR), the DoS receives all export license applications from NASA and Agency contractors for exports and services subject to the ITAR, including many space-related items. OIIR works with the DoS Directorate for Defense Trade Controls and the Bureau of International Security and Nonproliferation on a regular basis to resolve ITAR-related issues impacting NASA programs and to address the appropriate use of technologies controlled by the Missile Technology Control Regime. In addition, NASA participates with the Department of State-led interagency delegation to the quadrennial World Radiocommunications Conference of the International Telecommunications Union, which establishes the international agreements on radiofrequency allocation, in order to ensure NASA's access to the required frequencies for all its current and future missions.

REGULATORY EFFORTS WITH OTHER AGENCIES

NASA works closely with other U.S. Government regulatory agencies to facilitate necessary licenses, permits, and approvals required to successfully implement NASA's missions. These include cooperation with the Department of Homeland Security for customs clearance, NASA duty-free import certifications, consultations with the Department of Justice on export control enforcement matters, and obtaining necessary permits from the U.S. Department of Agriculture, the Food and Drug Administration (FDA), and other entities for imports of foreign-provided food for transport to International Partner astronauts aboard the ISS. NASA is represented on the Treasury Department's Committee on Foreign Investment in the United States, a regulatory body that implements the requirements of the Exon-Florio Act for U.S. Government review of foreign acquisitions with national security implications.

PROGRAMMATIC COOPERATION WITH OTHER INDIVIDUAL AGENCIES

NASA cooperates extensively with other Federal agencies on a wide range of joint program efforts. These interagency cooperative efforts occur at all levels within the Agency. NASA researchers collaborate directly with colleagues from other agencies in conferences, joint projects, and personnel exchanges. Program officials meet to coordinate complementary program efforts, and NASA belongs to numerous joint planning committees, ranging from working groups to senior-level management committees. Formal documentation of such interagency cooperation includes interagency Memoranda of Agreement, typically signed by senior officials of each agency. For example:

U.S. GEOLOGICAL SURVEY (USGS)

NASA works closely with the Department of the Interior's USGS on land-remote sensing programs, such as Landsat.

NATIONAL SCIENCE FOUNDATION (NSF)

NASA interacts regularly with NSF to coordinate cooperative space science research activities.

DEPARTMENT OF HEALTH AND HUMAN SERVICES (HHS)

NASA has several agreements with the agencies and offices under HHS, including the National Institutes of Health and the Centers for Disease Control and Prevention, and Food and Drug Administration for joint projects to improve human health on Earth and in space. NASA also engages with HHS and the National Institutes of Health on topics related to the economic development of low Earth orbit.

DEPARTMENT OF ENERGY (DOE)

NASA and DoE have enjoyed decades of cooperation on matters involving space nuclear power and science, as well as non-nuclear power-related technologies. The agencies additionally consult on broader policy efforts.

FEDERAL AVIATION ADMINISTRATION (FAA)

NASA maintains a partnership with the FAA in both policy and program areas through participation on FAA advisory committees, executive committees, aviation rulemaking committees, safety teams and payload reviews, and by working jointly with the FAA on Joint Planning and Development Office boards and Research Transition Teams. NASA focuses on new technology, while the FAA works to bring the technology into operational use and develop standards. Current partnership efforts include demonstrating new air traffic management technologies to enable and motivate faster technology insertion and equipage rates by airline operators; reducing technical barriers to allow routine access by unmanned aircraft systems to the airspace; and finding faster, less expensive verification and validation methods for highly complex systems to reduce cost, schedule, and implementation risks of the next generation air traffic control system, including certification of new aircraft. NASA also works closely with the FAA to develop standards for the commercial human spaceflight sector.

SPACE POLICY MATTERS

NASA, via OIIR, routinely liaises with the White House Office of Science and Technology Policy (OSTP) and the National Security Council (NSC) and coordinates regularly on matters concerning space policy, significant space-related events such as spacecraft reentries, and other matters.

OSTP was established in 1976 to coordinate the Nation’s science and technology investment and provide policy advice to the President. The Director of OSTP also serves as the President’s Science Advisor. The NSC is the President’s principal forum for considering national security and foreign policy matters. The NSC also serves as the President’s principal arm for coordinating these policies among various government agencies, including NASA. The NSC staff leads regular interagency meetings to discuss space policy matters, as well as to resolve issues in dispute.

NASA INTERACTION WITH FOREIGN ENTITIES

NASA'S INTERACTION WITH FOREIGN ENTITIES

International cooperation is a significant component of the NASA mission established in the National Aeronautics and Space Act of 1958 and further articulated in U.S. National Space Policy of June 2010. NASA adheres to longstanding policy guidelines on international space cooperation, including the fundamental principles that international partnerships must:

- Generally involve no exchange of funds;
- Have scientific and technical merit;
- Directly benefit NASA's mission; and
- Be structured to establish clearly defined managerial and technical interfaces while protecting against unwarranted technology transfer.

NASA's programs traditionally have had a strong international component, and international activities continue to grow.

Due to the level of commitments required, NASA generally partners with foreign government agencies responsible for space and aeronautics activities, and has longstanding and robust relationships with several of these in particular. These include the space agencies of Russia, Japan, Canada, France, Germany, Italy, the United Kingdom, and the European Space Agency (ESA). NASA continually seeks new opportunities for mutually beneficial cooperation with these key partners, and increasingly also with emerging partners in countries with which there has traditionally been less cooperation.

Currently, NASA has over 750 agreements with more than 120 countries. Six foreign partners account for 64 percent of these agreements: France, Germany, the European Space Agency, Japan, Canada, and the United Kingdom. NASA has also in recent years undertaken a focused effort to engage non-traditional partners in support of NASA's mission objectives. This effort has built upon existing relationships and new relationships with countries that have had no experience working with NASA. Two emerging partners, India and China, are of particular note: the former for the greatly increased scope of collaboration in recent years, a trend which will likely continue, and the latter for the considerable growth in its accomplishments and capability in human and robotic exploration.

International cooperation contributes in varying degrees to the objectives of each of NASA's Mission Directorates. The foremost example is the International Space Station (ISS) Program, the most ambitious international cooperative program in NASA's history. Under the Human Exploration and Operations Mission Directorate (HEOMD), the ISS is a partnership among 15 nations led by NASA and implemented in cooperation with ESA and the space agencies of Russia, Canada and Japan. Construction began in November 1998, and international crews have continuously inhabited the station since November 2000. Astronauts from each of the ISS partners serve as ISS crew members. The partnership is formalized under the ISS Intergovernmental Agreement ('the IGA'), which allows for non-reimbursable cooperation, including barter and common system operations costs (CSOC) arrangements.

Looking to the future of human space exploration beyond the ISS and low Earth orbit, NASA is engaged with international stakeholders at multiple levels, including ISS partner agencies through the Multilateral Coordination Board (MCB) and Heads of Agency (HOA) meetings.

The agency also coordinates with civil space organizations from 15 countries who participate in the International Space Exploration Coordination Group (ISECG). NASA is currently developing a future exploration strategy that will seek to build on the ISS partnership and enable multilateral human spaceflight cooperation beyond LEO.

Of the NASA Science Mission Directorate's (SMD) more than 100 planned or operating missions, approximately two-thirds involve contributions by international partners. These partnerships arise both through engagements between U.S. scientists with their colleagues around the world to respond to NASA's competed space and Earth science missions, as well as through strategic coordination among traditional partners, especially ESA, the Japan Aerospace Exploration Agency (JAXA), and the space agencies of France, Germany, and Italy. As noted below, a significant recent development is the inclusion of the Indian Space Research Organisation (ISRO) as a strategically important partner in SMD missions.

Compared to the pervasiveness of international cooperation in HEOMD and SMD missions, such partnerships make a comparatively modest contribution to NASA's Aeronautics Research Mission Directorate (ARMD) and Space Technology Mission Directorate. This is due to NASA's practice of foregoing cooperation that could convey a competitive advantage to foreign commercial interests, and to its general policy against conducting joint technology development with international partners. However, in recent years ARMD has taken a more strategic approach to its international partnerships, focusing on key areas such as air traffic management (ATM) and alternative fuels research, which could provide significant benefits to U.S. industry. NASA has also led in the creation of the 26-member International Forum for Aviation Research (IFAR), the only government-sponsored aviation research network in the world. NASA's leadership of IFAR enables it to identify promising areas for cooperation. For example, NASA currently has five active ATM agreements with IFAR members and expects to sign an ATM agreement with the Chinese Aeronautical Establishment in the near future, which would represent the first new agreement between NASA and a Chinese entity in over 20 years.

KEY PARTNERS: CANADA, EUROPE, JAPAN, AND RUSSIA

NASA has a long history of successful cooperation with Canada, Europe, Japan, and Russia. These partners have well-developed space capabilities and continue to make significant contributions to variety of ongoing and planned NASA programs. Cooperation with these partners spans the breadth of NASA's Mission Directorates, as discussed below.

CANADA

Canada provided robotic systems for the ISS and is cooperating with NASA on the James Webb Space Telescope and on the OSIRIS-REx asteroid mission (launched in September 2016). Other areas of current cooperation with NASA are in space and Earth science. Canada's expertise lies mainly in robotics and space radar systems, the latest of which, the RADARSAT Constellation Mission (RCM), is due to launch in fall 2018. In April 2015, Canada announced its commitment to continue ISS operations to 2024. With its ISS development work complete and RCM nearing completion, Canadian Space Agency officials are considering future investments to sustain the country's space industry capacity, as part of the government's "Innovation Agenda," to be announced in fall 2016. While the government's budget has been impacted by falling oil prices and unfavorable exchange rates, deficit spending to stimulate growth is expected, which could make more resources available for cooperative activities.

EUROPE

The European Space Agency (ESA), headquartered in Paris, is comprised of 22 member nations. NASA has excellent, longstanding relations both with ESA and bilaterally with several of its Member States with robust national space agencies and programs, most notably France, Germany, the United Kingdom, and Italy. NASA cooperates with ESA on the ISS, to which ESA contributed the Columbus Research Laboratory. NASA is currently cooperating with ESA on the latter's provision of the Service Module for the Orion crew vehicle's first two Exploration Missions, with the expectation of future European Service Modules for Orion. NASA also cooperates with ESA in a broad array of space and Earth science projects. NASA's significant cooperation with France, Germany, and Italy spans all NASA Mission Directorates. ESA is the only ISS partner that has not yet declared its commitment to extending ISS operations until 2024. In December 2016 ESA's governing body, the ESA Council, will meet at Ministerial level to decide on a number of pressing issues including ISS extension. Noting competing pressures on European budgets (arising from migration of refugees and other urgent needs), NASA conducted a series of focused engagements with European officials throughout 2016 to bolster European-wide support for NASA's mid- and long-term exploration goals. A positive ESA decision on ISS extension through at least 2024 is considered likely at present.

JAPAN

NASA has strong cooperation with Japan in nearly every mission area, including human spaceflight, space science, Earth science, and aeronautics. Japan cooperates with NASA on the ISS, to which it contributed the Japanese Experiment Module called Kibo. In the past several years, the emphasis of Japanese space policy has shifted toward security, maintenance of the Japanese industrial base, commercialization of Japanese capabilities, and disaster monitoring. This reprioritization has come at the expense of significant new investment in science and exploration. A new ten-year mission roadmap and budget request for the next fiscal year (beginning April 1, 2017) will be released in late 2016. The two mission areas under the most pressure to demonstrate return on investment are human spaceflight and Earth science, both of which are being closely examined from a budget and policy perspective. In December 2015, the Government of Japan took the decision to extend participation in the ISS program through at least 2024. In parallel, the U.S. and Japan agreed to pursue cooperation under the U.S.-Japan Open Platform Partnership Program (OP3), a non-binding outline of overarching goals for utilization activities on the ISS through which the Government of Japan expects enhanced cooperation with NASA and broader utilization of Kibo.

RUSSIA

Despite serious challenges in U.S.-Russia relations, the ISS and ongoing science mission collaborations have not been significantly impacted. NASA has an extensive history of cooperation with Russia, from such significant activities as the Apollo-Soyuz Test Project and the Shuttle-Mir program, to space science, Earth science, and space biology and medicine. Russia became a full partner in the International Space Station in the late 1990's. In addition to Soyuz crew vehicles and Progress cargo vehicles, Russia provided several of the ISS's modules, including some core functions for the overall ISS. Maintaining its human spaceflight capability in low Earth orbit is a high priority for the Russian government, which in July 2015, approved ISS extension to 2024 with little fanfare. Instruments provided by the Russian Academy of Sciences also continue to operate on NASA's Lunar Reconnaissance Orbiter, Mars Odyssey, and Curiosity.

SIGNIFICANT EMERGING PARTNERS: INDIA AND CHINA

INDIA

India has committed to enhancing its space capabilities across a broad range of activities, including launch vehicles; Earth remote sensing, space science, communication and navigation; and, in the long term, human spaceflight. The Indian Space Research Organisation (ISRO) has enjoyed generous budget growth over the past decade and has demonstrated significant accomplishments including putting a spacecraft in Mars orbit. Over the past five years, NASA and ISRO have developed a strong foundation for mutually beneficial cooperation.

Beginning with the launch of two NASA instruments on India's Chandrayaan-1 lunar mission in 2008, NASA's cooperation with ISRO has steadily expanded in size and scope. It now spans many program areas, including Earth science, planetary science, and education. The foremost example of this expanded cooperation is the joint NASA-ISRO Synthetic Aperture Radar (NISAR) mission, a spacecraft to which both agencies are contributing key science instruments and which will launch on an Indian vehicle in 2021. Discussions on future collaborative activities are taking place in a number of forums, including a NASA-ISRO Mars Working Group established in September 2014, ongoing discussions on cooperation in heliophysics and space communications and navigation, and a recently concluded airborne campaign involving the flight of a next generation visible/infrared imaging spectrometer instrument on an ISRO B-200 plane in India. NASA and ISRO have also begun discussions on respective human spaceflight activities and plans, as an early step toward positioning for future human spaceflight collaboration.

CHINA

China has pursued a highly ambitious space program across the full spectrum of space activities from Earth and space science to robotic and human exploration. As national remote sensing, meteorology, and Earth observation satellite programs continue to improve, the country also is planning two new missions to the moon, one a sample return mission in 2017 and the other to land on the far side of the moon in 2018, as well as sending a rover to Mars by 2020. China has conducted five crewed missions with ten astronauts and recently launched an orbiting laboratory module (Tiangong-2) in September 2016, to be followed by a docking with the Shenzhou crewed spacecraft in October. The current plan is to assemble and complete a small space station by 2022.

NASA's ability to collaborate with China is constrained by statute, in particular by the FY2016 Consolidated Appropriations Act. NASA is prohibited from bilateral cooperation with Chinese entities unless the Agency certifies to Congress that such activities pose no risk of resulting in the transfer of technology, data, or other information with national security or economic security implications to China, and that they do not involve knowing interactions with key officials who have been determined by the United States to have direct involvement with violations of human rights. NASA has certified cooperation with China in five areas: exchanges of data related to space geodesy; research to characterize the status of glaciers in the Himalayas; exchange of lunar science mission data; engagement related to carbon dioxide monitoring from space; and Air Traffic Management research. The latter is the subject of the first international agreement between NASA and the Chinese government in over 20 years, which was signed September 27, 2016.

NON-TRADITIONAL PARTNERS

Worldwide collaboration is essential for NASA in addressing the inherently global and interrelated scientific challenges of robotic and human exploration, understanding the Earth as a system, or solving technical issues related to air traffic management and aviation safety. Additionally, more and more nations are developing the capability and interest to significantly contribute to space exploration, to foster technology innovation, and to utilize space for the benefit of their citizens. Whether to close geographic gaps in scientific measurements; calibrate and validate spacecraft; secure access to data; leverage other nations' unique capabilities or advantages such as geography or resources; bring the benefits of space for societal development; or promote science, technology, engineering, and mathematics (STEM) education, NASA has in recent years expanded its reach to non-traditional partners in Asia, Latin America, the Middle East, and Africa. From South Korea, whose cooperation with NASA now includes aeronautics, Earth and space science, lunar robotic exploration, and space communications activities, to the United Arab Emirates (UAE), with whom NASA recently signed an agreement for cooperation on the UAE's 2020 Mars mission, NASA's cooperation with non-traditional partners extends to all parts of the globe and continues to grow.

NASA INTERACTION WITH ACADEMIA AND INDUSTRY

INDUSTRY'S INVOLVEMENT IN NASA'S WORK

More than 81 % of NASA funding is obligated through procurements. Contractors perform an important role in helping NASA accomplish its mission. In FY 2015, NASA's procurements totaled $17,191.5 million for 40,710 procurement actions. Contracts are used to procure major end items, support services, and small purchases. During FY 2015, private sector organizations in all 50 states and the District of Columbia participated in NASA procurements. Additional detail can be found in ***NASA'S FY 2015 ANNUAL PROCUREMENT REPORT*** - *https://prod.nais.nasa.gov/pub/pub_library/annual_proc_reports_index.html*

In addition, NASA leverages the Space Act to form agreements with industry for the development of the Commercial Space Transportation Program. Through this innovative approach to working with industry, NASA is able to judiciously bring to bear the right combination of skills and capabilities from private industry, in precisely the amount needed, to further America's space goals.

AWARDS BY TYPE OF CONTRACTOR

In FY 2015, most of the contracts (74 %) were awarded to business firms, followed by awards to Caltech JPL (11 %), educational institutions (5 %), and nonprofit organizations (5 %). The remaining 5 % of the contracts were awarded to other government agencies (2 %) and to companies/organizations outside of the U.S. (3 %).

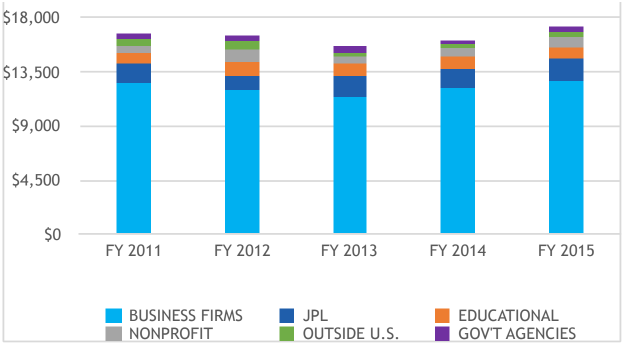


Figure 11.1 Trends in Awards by Type of Contractor $ (In Millions)

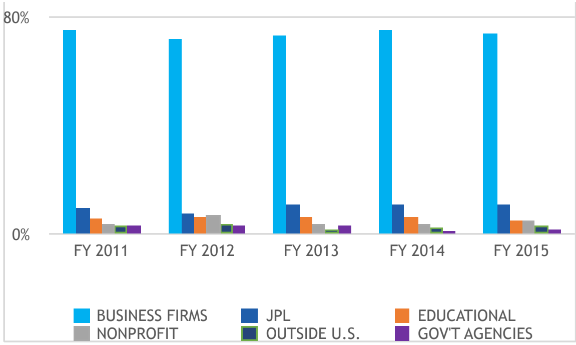


Figure 11.2 Trends in Awards by Type of Contractor %

NASA maintains a list of the top 100 contractors. These contractors accounted for 90.2 % of the monetary awards to business firms during the year and can be found in the FY 2015 Annual Procurement Report. Of the top 100 contractors, 44 were small business firms, and of these, 26 were disadvantaged firms at the time of award.

AWARDS BY CONTRACT TYPE

Different types of contracts are used to perform different types of work. Firm fixed price contracts are low-risk to the Government and are used for services and supplies when the work is well-defined. When the work is less well defined, especially for research and development contracts, cost-plus contracts are used.

Although very few award fee contracts are used throughout the Agency, a large percentage (49 %) of procurement obligations were awarded under cost plus award fee and fixed price award fee contracts in FY 2015. NASA has made an effort to reduce the number of award fee contracts used. As a result, this number has been steadily trending down. Firm Fixed Price contracts represented 34 % of the contracts awarded. Four years ago, this number was 20 %. Cost Plus Fixed Fee is at 13 %, Incentive Fee Contracts at 3 %, and other award structures at 1 %.

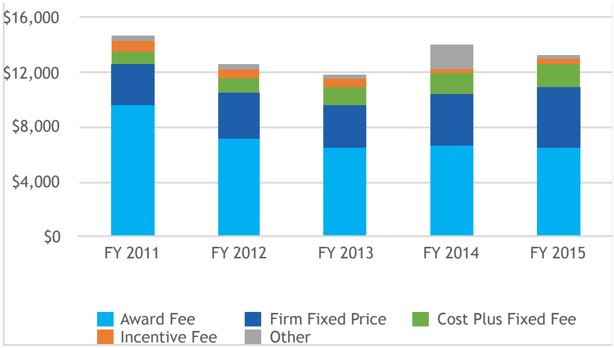


Figure 11.3 Awards to Business Firms by Contract Type $ (In Millions)

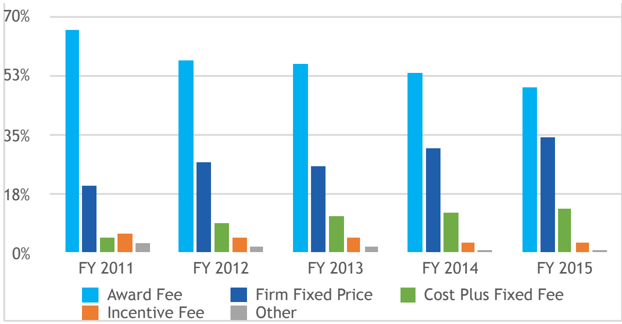


Figure 11.4 Awards to Business Firms by Contract Type %

ROLE OF COMPETITION

The Competition in Contracting Act (P.L. 98-369), with limited exceptions, requires full and open competition within the federal government. Full and open competition means that all responsible sources are permitted to submit sealed bids or competitive proposals on a given procurement. Contracting without providing for full and open competition is allowable under certain circumstances. Written justifications are required to award procurements on contracts awarded via other than a full and open competition basis. In FY 2015, 67.8 % of the net value of contracts were competed, and 32.2 % of the net value were not competed. The trend for NASA reflects increasing competition for FY 2011-2015.

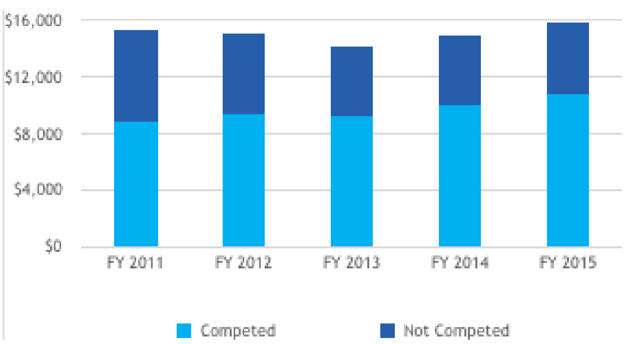


Figure 11.5 Trends in Awards by Extent of Competition $ (In Millions)

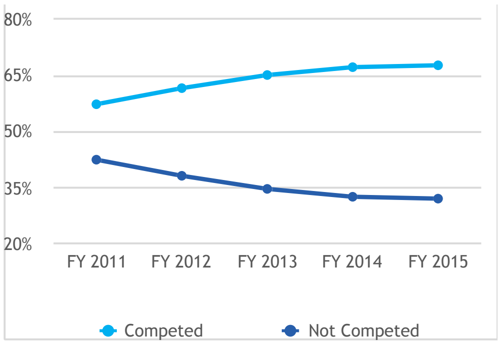


Figure 11.6 Trends in Awards by Extent of Competition %

CONTRACT SELECTION PROCESS FROM ACQUISITION STRATEGY PLANNING TO AWARD

NASA contracting is accomplished through NASA Field Centers outside of Washington, D.C. At NASA, procurement authority flows from the President of the United States to the NASA Administrator, the Associate Administrator, the Chief Financial Officer, the Assistant Administrator for Procurement Center Directors, and Center Procurement Officers. The Associate Administrator is the Chief Operating Officer responsible for strategic and performance planning for agency missions. The Chief Financial Officer is NASA's appointed Chief Acquisition Officer, and provides high level oversight of the acquisition function. NASA's Deputy Chief Acquisition Officer is the Assistant Administrator for Procurement. There is an informal reporting relationship between the two positions, with day-to-day management delegated to the Procurement Executive. The Center Procurement Officers have authority to award procurements subject to review of major actions by Headquarters. The contract and acquisition planning process operates under policy and oversight by the Headquarters Office of Procurement.

The Federal Acquisition Regulations (FAR) and the NASA FAR Supplement (NFS) are the regulations governing NASA's acquisition planning process through award. The NASA acquisition planning process is separated into three discrete events, leading to a procurement: the Strategy Implementation Planning (SIP) process that guides specific budget and acquisition decisions, the Acquisition Strategy Meetings (ASM) where senior Agency management review and approve program and project acquisition strategies, and the Procurement Strategy Meeting (PSM) (see NFS 1807.170) for acquisitions requiring Headquarters approval.

NASA'S DOMESTIC PARTNERSHIPS PORTFOLIO

NASA'S DOMESTIC PARTNERSHIPS PORTFOLIO WEBSITE *- http://www.nasa.gov/partnerships/about.html*

In addition to NASA's contracts, grants, and cooperative agreements, NASA also engages in various partnerships to conduct research, promote STEM education, and otherwise advance NASA's missions. These partnerships are done under NASA's "other transactions authority" (OTA) of the National Aeronautics and Space Act (the Space Act) and are commonly referred to as Space Act Agreements (SAAs). Unlike contracts, grants, and cooperative agreements, where NASA is providing funding, SAA's are usually conducted on a non-reimbursable basis where neither party is providing funding to the other, or on a reimbursable basis where the partner reimburses NASA for access to unique NASA resources in support of the partner's activity.

NASA has 2,301 active domestic partnership agreements (non-procurement-type activities) with a variety of U.S. entities including commercial industry, educational institutions, not-for-profits, and Federal, state, and local governments. NASA does not acquire goods and services through partnership agreements.

Figure 11.7 illustrates NASA's 2,301 active domestic agreements (as of August 23, 2016) by partner type.

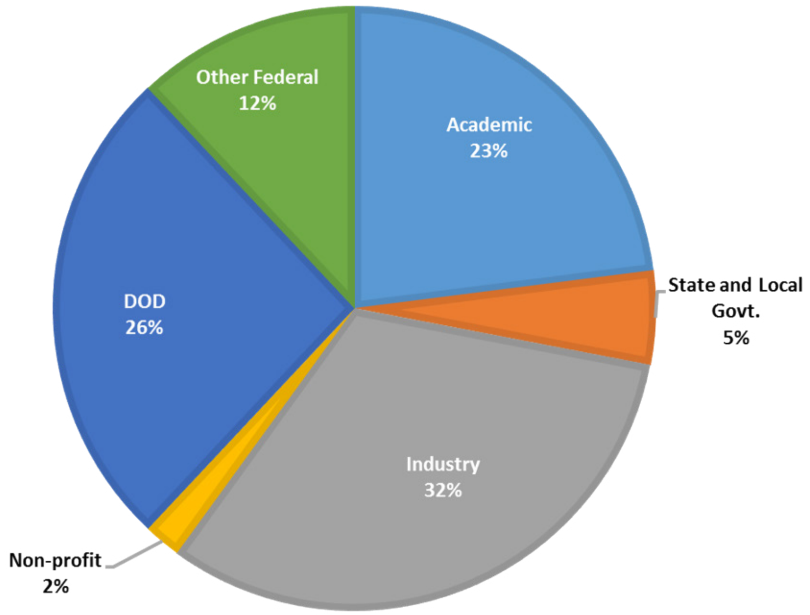


Figure 11.7 Domestic Partnerships Active Agreement Pie Chart

NASA'S DOMESTIC PARTNERSHIPS PORTFOLIO

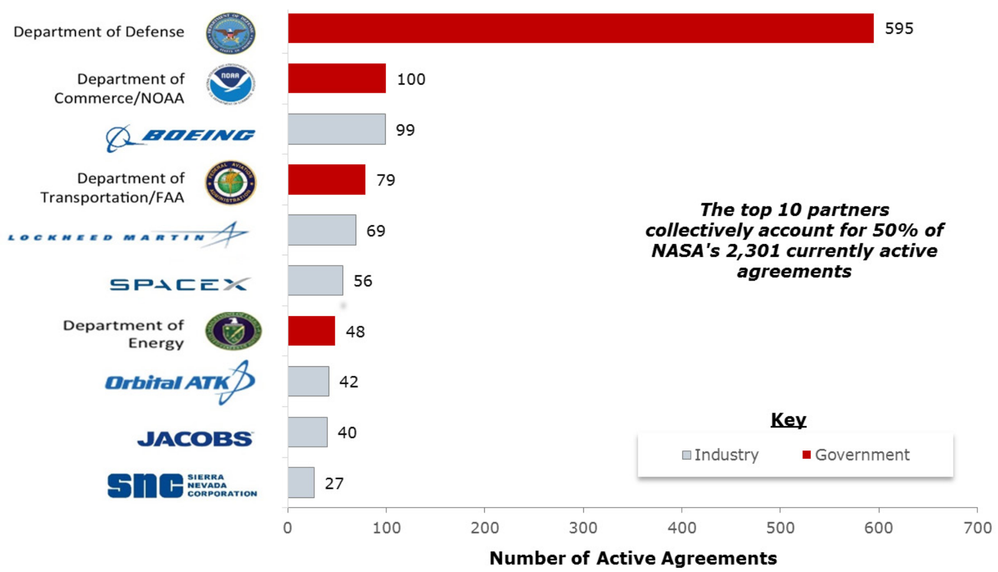


Figure 11.8 NASA's Top Domestic Partners by Number of Partnership Agreements

EXAMPLES OF CURRENT NASA PARTNERSHIPS

- Reimbursable agreement with a U.S. company to assist the partner in its efforts to develop and demonstrate launch vehicle propulsion technology. The NASA support includes providing advice and assistance in the design of rocket engine components, analysis of the partner's designs using computer simulations, testing of materials and components under simulated launch conditions, and developing methodologies using additive manufacturing.

- Non-reimbursable (no exchange of funds) agreement with a U.S. university to make available a Fireball Network Station at the university that will monitor the night sky in order to detect bright meteors (a.k.a. fireballs) and disseminate resultant data to NASA scientists and to selected educators who may incorporate the data into the classroom.

- Reimbursable agreement with the U.S. Air Force to conduct a force and moment wind tunnel test program in NASA's Aerodynamic Research Facility 14-inch Trisonic` Wind Tunnel.

- Non-reimbursable (no exchange of funds) agreement with U.S. high schools for participation in the High Schools United with NASA to Create Hardware (HUNCH) Program. The goal of the program is to inspire the next generation of explorers through hands-on projects for students.

- Non-reimbursable (no exchange of funds) agreement with a U.S. non-profit, volunteer-led organization to collaborate to inspire and equip students to become the next generation of innovators and leaders. The program encourages teams of learners to have fun, take risks, focus, and frame challenges while incorporating STEM (science, technology, engineering, and mathematics), the arts, and service learning.

- Non-reimbursable (no exchange of funds) agreement between NASA and a U.S. university to collaborate in support of the National Center for Advanced Manufacturing.

NASA FEDERAL ADVISORY COMMITTEES AND NATIONAL ACADEMIES

FEDERAL ADVISORY COMMITTEES

NASA's top two Federal advisory committees, the NASA Advisory Council (NAC) and Aerospace Safety Advisory Panel (ASAP), are key sources of external independent advice to the Agency from nationally and internationally recognized aerospace experts. Over the past year, both the NAC and ASAP have focused their advice in a number of critical areas. For example, the NAC has provided recommendations related to NASA's Journey to Mars, the Asteroid Redirect Mission, and IT security. The ASAP has provided recommendations related to Orion risk assessment, and human spaceflight mishap response. The most recent ASAP Annual Report for 2015 to the NASA Administrator and Congress (released in January 2016) provided safety assessments, insights, and perspectives on NASA's Commercial Crew Program, the International Space Station, and Exploration Systems Development (Orion and Space Launch System).

NASA FEDERAL ADVISORY COMMITTEES

NASA has traditionally sought independent judgment and guidance from scientific and technical experts in academia, industry, and other government agencies. Since 1958, NASA has turned to highly accomplished citizens and world-class experts to provide advice, findings, and recommendations on major programmatic and policy issues related to the U.S. civil space program. NASA's Federal advisory committees, formally chartered under the Federal Advisory Committee Act (FACA), have specific goals, objectives, charters, appointed members, and specified durations for their work. NASA's current six Federal advisory committees include:

- NASA Advisory Council (NAC)
- Aerospace Safety Advisory Panel (ASAP)
- Applied Sciences Advisory Committee (ASAC)
- International Space Station (ISS) Advisory Committee
- International Space Station National Laboratory Advisory Committee (INLAC)
- National Space-Based Positioning, Navigation and Timing (PNT) Advisory Board

NASA ADVISORY COUNCIL

COUNCIL WEBSITE - http://www.nasa.gov/offices/nac/home/index.html

The NASA Advisory Council (NAC) was formally created in 1977 by combining two pre-existing Agency-level advisory committees into a larger, more comprehensive body of experts. These two pre-existing advisory committees were the Space Program Advisory Council and the Research and Technology Advisory Council. The NAC reports directly to the NASA Administrator and is the most senior body charged with developing findings and recommendations across the breadth and depth of NASA's programs, policies, and plans for consideration by the NASA Administrator and Agency senior leadership. All formal recommendations to NASA are carefully considered and receive a formal Agency response. The NAC is currently comprised of the Council, five standing committees, six subcommittees, and two task forces, as folows:

- Aeronautics Committee
- Human Exploration and Operations Committee
  - *Research Subcommittee*
- Institutional Committee
- Science Committee
  - *Astrophysics Subcommittee*
  - *Earth Science Subcommittee*
  - *Heliophysics Subcommittee*
  - *Planetary Protection Subcommittee*
  - *Planetary Science Subcommittee*
  - *Ad Hoc Task Force on Big Data*
- Technology, Innovation and Engineering Committee
- Ad Hoc Task Force on Science, Technology, Engineering and Mathematics (STEM) Education

The current charter of the NAC was signed by the NASA Administrator on October 21, 2015, and has a duration of two years. The NAC typically meets three times per year.

AEROSPACE SAFETY ADVISORY PANEL

The U.S. Congress directed NASA to establish the Aerospace Safety Advisory Panel (ASAP) following the 1967 Apollo-1 fire on the launch pad that resulted in the death of three NASA astronauts. The NASA Authorization Act of 1968 (Public Law 90-67) set forth the statutory duties for the Panel. More recently, the Panel's duties have been codified at 51 U.S.C., Section 31101. The purpose of ASAP is to advise the NASA Administrator and the Congress on matters related to safety in NASA's aerospace programs. All formal Panel recommendations to NASA are carefully considered and receive a formal response from the Agency. The Panel is required to submit an annual report to the NASA Administrator and to the Congress. The charter for the Aerospace Safety Advisory Panel is renewed every two years. The Panel typically holds four quarterly meetings and several focused "insight" visits each year to NASA Centers or its key contractors.

APPLIED SCIENCES ADVISORY COMMITTEE

In the NASA Authorization Act of 2005 (Public Law 109-155), the U.S. Congress directed NASA to establish the Applied Sciences Advisory Committee (ASAC). Its purpose is to provide advice and make recommendations to the Director of the Earth Science Division (within the Science Mission Directorate) on Earth science applications and applied sciences programs, policies, plans and priorities, including the role of applied sciences within and outside of NASA. The charter for the Applied Sciences Advisory Committee is renewed every two years. The ASAC typically meets once or twice per year.

INTERNATIONAL SPACE STATION (ISS) ADVISORY COMMITTEE

In 1994, NASA established the NASA Advisory Council (NAC) Task Force on the Shuttle-Mir Rendezvous and Docking Missions to review the planning, training, rendezvous/docking, operations, and management of the Shuttle-Mir Program. Later that year, following direction from the U.S./Russian Joint Commission on Economic and Technological Cooperation (the "Gore-Chernomyrdin Commission") to establish a joint NASA-Russian Space Agency process for reviewing the Shuttle-Mir Program, the task force became a joint review committee focused on issues of safety and reliability. In 1998, the Joint Commission began to focus its attention on the safety and operational readiness of the International Space Station (ISS), and in 1999 was renamed the NAC Task Force on ISS Operational Readiness. In 2006, this Task Force was formally chartered as a separate NASA Federal advisory committee under FACA, and was renamed the ISS Advisory Committee. It reports to the NASA Associate Administrator for the Human Exploration and Operations Mission Directorate. The ISS Advisory Committee and its predecessors have been a valuable source of expert opinion to the ISS program. The trust built between the ISS Advisory Committee members and their Russian counterparts has engendered valuable insight into their respective space programs and facilitated open and candid communications. The ISS Advisory Committee charter is renewed annually. The ISS Advisory Committee typically meets two times per year.

INTERNATIONAL SPACE STATION (ISS) NATIONAL LABORATORY ADVISORY COMMITTEE

The establishment of the International Space Station (ISS) National Laboratory Advisory Committee was directed by the U.S. Congress in the NASA Authorization Act of 2008 (Public Law 110-422). More recently, the ISS National Laboratory Advisory Committee duties have been codified at 51 U.S.C., Section 70906. The purpose of this NASA Federal advisory committee is to monitor, assess, and make recommendations regarding effective utilization of the ISS as a National Laboratory and platform for research. The committee was formally chartered by NASA in 2009. However, in 2011, NASA established a nongovernmental nonprofit organization to manage the National Laboratory for U.S.-sponsored ISS research activities, the Center for Advancement of Science in Space (CASIS), whose Board of Directors would accomplish the functions set forth in the charter for the ISS National Laboratory Advisory Committee. As such, the ISS National Laboratory Advisory Committee has been dormant; no members have been appointed and it has never met. NASA intends to work with the U.S. Congress in the coming months to seek legislative assistance to repeal the statutory provision mandating the establishment of the ISS National Laboratory Advisory Committee and terminate its charter.

NATIONAL SPACE-BASED POSITIONING, NAVIGATION AND TIMING ADVISORY BOARD

The National Space-Based Positioning Navigation and Timing (PNT) Advisory Board was established by NASA in 2006 to implement national space policy related to the U.S. Global Positioning System (GPS), specifically, the U.S. Space-Based Positioning, Navigation, and Timing Policy (National Security Presidential Directive-39) that was announced by the White House in December 2004. This Presidential Directive created a permanent National Space-Based PNT Executive Committee comprised of seven Federal agencies:

- Department of Defense
- Department of Transportation
- Department of State
- Department of Commerce
- Department of Homeland Security
- Joint Chiefs of Staff
- NASA

In 2007, the PNT Executive Committee was expanded to add two Federal agencies:

- Department of Agriculture
- Department of the Interior

The PNT Executive Committee is co-chaired by the Deputy Secretaries of Defense and Transportation, and the PNT Advisory Board's role is to provide expert advice to the PNT Executive Committee on U.S. space-based PNT policy, planning, program management, and funding profiles in relation to the current state of national and international space-based PNT services. Board findings and recommendations have been considered in the development of national PNT strategy and in developing annual updates to the Five-Year Space-Based PNT Plan. Board members, including several foreign members, represent a broad spectrum of GPS expertise across critical industry sectors, academia, and users. The charter for the PNT Advisory Board is renewed every two years. The PNT Advisory Board typically meets two times per year.

NATIONAL ACADEMIES

NASA has a longstanding tradition of seeking external independent technical assessments, studies, and expert advice from the National Academies: the National Academy of Sciences; the National Academy of Engineering; and the Institute of Medicine. The National Academies encourage education and research, recognize outstanding contributions to knowledge, and increase public understanding in matters of science, engineering, and medicine. The National Academies' service to government has become so essential that Congress and the White House have issued legislation and executive orders over the years that reaffirm its unique role.

The three Academies work together as the National Academies of Sciences, Engineering, and Medicine to provide independent, objective analysis and advice to the Nation and conduct other activities to solve complex problems and inform public policy decisions.

The National Academies manage two key independent advisory bodies for NASA:

- Space Studies Board
- Aeronautics and Space Engineering Board

The Space Studies Board (SSB) Provides recommendations from the U.S. scientific community to NASA through decadal surveys (DSs), mid-term assessments and other technical reports for each of NASA's four major science disciplines – Earth science, heliophysics, planetary science and astrophysics. The DSs, a primary vehicle for SSB advice, represent the broad consensus of the nation's scientific communities and are the starting point for NASA's strategic planning process in the areas of Earth and space sciences. The most recent DSs are as follows: Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond (2007), New Worlds, New Horizons in Astronomy and Astrophysics (2010), Vision and Voyages for Planetary Science in the Decade 2013–2022 (2011), and Solar and Space Physics: A Science for a Technological Society (2013). The next DS that will be received is the upcoming Decadal Survey for Earth Science and Applications from Space 2017-2027, expected in late 2017. Given appropriated budget levels and executive and Congressional direction, NASA transforms the DS priorities into an executable portfolio that is balanced betweenV and within each science discipline. Every four years, SMD issues a Science Plan (most recently issued in 2014) that describes the integrated, executable portfolio for all of SMD.

LINKS

NATIONAL ACADEMY OF SCIENCES
http://www.nasonline.org/about-nas/organization/

PRESS RELEASE ON NATIONAL ACADEMY OF SCIENCES
http://www.nasa.gov/press-release/nasa-awards-aeronautics-space-programs-policies-study-contract/

NATIONAL ACADEMIES OF SCIENCES, ENGINEERING, AND MEDICINE
http://www.nationalacademies.org/

MAJOR MISSION PROFILES

APPROACH TO MISSIONS

For more than a century the nation has had confidence in turning to NASA and its predecessor organization, the National Advisory Committee for Aeronautics, for solutions to aviation's biggest challenges in the air and on the ground. The resulting technology developed through the years by NASA's world-class aeronautical innovators today finds itself aboard every U.S. aircraft and inside every air traffic control facility in the country. NASA continues to team with industry, academia, and other government agencies, including the Federal Aviation Administration (FAA) and the Department of Defense (DoD). Now with NASA and its rich research heritage at the heart of this ongoing collaboration, the stage is set to enable a new era in aviation as revolutionary to the world as the introduction of the commercial jet age during the 1960s and the invention of flight itself in 1903.

The Aeronautics Research Mission Directorate (ARMD) has documented this transformative potential in its Strategic Implementation Plan (SIP). The SIP lays out the future of U.S. aviation's public-private research partnership in six key Strategic Thrusts. The Strategic Thrusts and their accompanying roadmaps lay out the plan to achieve visionary outcomes for continued U.S. leadership in a rapidly evolving and highly competitive global aviation system. A centerpiece for achieving this plan is ARMD's New Aviation Horizons initiative. This bold initiative aims to design, build and fly a series of five experimental aircraft or X-planes, depending on budget availability, over the next 10 years that will flight-validate the required new technologies, systems, and novel aircraft and propulsion configurations.

IMAGE 13.1

ARMD STRATEGIC IMPLEMENTATION PLAN - *http://www.aeronautics.nasa.gov/strategic-plan.htm*

APPROACH TO MISSIONS

HIGHLIGHTS OF KEY ACHIEVEMENTS FOR 2016

- Completed integration of the aircraft arrival automation with additional automation that organizes very efficient aircraft departure flows and aircraft surface movements.
- Developed, delivered, and validated, advanced physics-based design tools for low-sonic boom commercial supersonic aircraft.
- Validated performance and design of an advanced “Truss Braced Wing” (TBW) aircraft configuration through advanced computational fluid dynamics (CFD) assessments and high-fidelity wind tunnel testing.
- Completed the final flight tests and delivery of validation information to Radio Technical Commission for Aeronautics (RTCA) and FAA to enable finalization of Unmanned Aircraft Systems (UAS) Sense and Avoid (SAA) and Command and Control performance standards. These standards are an important step toward full integration of UAS in the National Airspace System (NAS).
- Demonstrated the first increment of a UAS Traffic Management (UTM) research platform. UTM is focused on enabling safe flight of small UAS at low altitude.

IMAGE 13.2

PROGRAMS

AIRSPACE OPERATIONS AND SAFETY PROGRAM

PROGRAM WEBSITE *- http://www.aeronautics.nasa.gov/programs-aosp.htm*

SHORT DESCRIPTION

The Airspace Operations and Safety Program (AOSP) develops and explores fundamental concepts, algorithms, and technologies to increase throughput and efficiency of the NAS safely. The program works in close partnership with the FAA and the aviation community to enable and extend the benefits of NextGen, the Nation's program for modernizing and transforming the NAS to meet evolving user needs. Integrated demonstrations of these advanced technologies will lead to clean air transportation systems and gate-to-gate efficient flight trajectories. The program is on the leading edge of research into increasingly autonomous aviation systems, including innovation in the management of UAS traffic and other novel aviation vehicles and business models. The program is not only providing critical research and development to ensure minimum safety requirements of Trajectory Based Operations, but is also pioneering the real-time integration and analysis of data to support system-wide safety assurance to enable proactive and prognostic aviation safety capabilities. AOSP directly supports three of the ARMD Strategic Thrusts (Thrust 1: Safe, Efficient Growth in Global Operations, Thrust 5: Real-time, System-wide Safety Assurance, and Thrust 6: Assured Autonomy for Aviation Transformation).

IMAGE 13.3

PROGRAMS

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017

- Airspace Technology Demonstration (ATD)-1 flight-deck interval management technologies flight test demonstrations of prototype flight hardware and software based on an algorithm for Airborne Spacing for Terminal Arrival Routes.
- ATD-2 Departure Metering demonstration of NextGen departure metering capability.
- Develop automated data mining and prognostic tools to identify and predict risk with near-time analysis capability.
- Demonstrate effective real-time safety notifications to operators within the terminal environment.
- Develop UAS Traffic Management (UTM) Technology Capability Level (TCL) 2 or increased phases of technology development, leveraging results from the TCL1 demonstration (August 2015) and focus on beyond visual line-of-sight (VLOS) operations in sparsely populated areas incorporating weather/wind integration, trajectory routing, object avoidance, and congestion management.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2018 – FY2020

- Develop UTM TCL3 focusing on requirements to manage separation by vehicle and/or ground-based capabilities under higher densities.
- Develop and deliver requirements, technologies, and training capabilities to the Commercial Aviation Safety Team (CAST) to enable reduced susceptibility to stall or upset conditions that can lead to aircraft loss-of-control.
- Develop and validate airspace integration performance requirements to enable large-scale VLOS and beyond VLOS access to UAS in low-altitude airspace in a final TCL4 demonstration.
- Develop and deliver an integrated metroplex traffic manager to the FAA NextGen and Air Traffic Organizations, flight operators, and airport operators.
- Develop and deliver air/ground technologies and procedures to the FAA and flight operators that enable reduced weather-induced delays.

PARTNER OVERVIEW

- **NASA Center(s):** Ames Research Center, Langley Research Center, Glenn Research Center
- **Federal Agencies:** FAA, FAA UAS Test Sites, DoD
- Other Government: the Port Authority of New York and New Jersey
- **Academia:** FAA Center of Excellence for UAS (ASSURE)
- **International:** German Space Agency (DLR), NLR (Netherlands), Japanese Space Agency (JAXA), Korean Aerospace Research Institute (KARI), French Aeronautics, Space, and Defense Research Lab (ONERA)
- **Industry:** The National Air of Traffic Controllers Association, American Airlines, United Airlines, Alaska Airlines, Virgin America, Charlotte Douglas International Airport, Honeywell, 65 agreements with industry such as Google, Amazon, Verizon, AT&T, Airware, Matternet, Qualcomm, Simulyze, Airmap, Skyward, General Electric, EasyJet, Southwest Airlines, Swiss Air, Boeing

IMAGE 13.4

ADVANCED AIR VEHICLES PROGRAM

PROGRAM WEBSITE - *http://www.aeronautics.nasa.gov/programs-aavp.htm*

SHORT DESCRIPTION

The Advanced Air Vehicles Program (AAVP) develops knowledge, technologies, tools, and innovative concepts to enable safe, new aircraft that will fly faster, cleaner, quieter, and use fuel far more efficiently. As the country continues to experience growth in both domestic and international air transportation, the AAVP helps to protect and preserve the environment. NASA research is inherent in all major modern U.S. aircraft, and the type of research performed by AAVP will prime the technology pipeline, enabling continued U.S. leadership, competitiveness, and jobs in the future. Technologies and design capabilities developed for these advanced vehicles will integrate multiple, simultaneous vehicle performance considerations, including fuel burn, noise, emissions, and intrinsic safety. Across the program, NASA will continue to engage partners from industry, academia, and other government agencies to maintain a sufficiently broad perspective on technology solutions to these challenges, pursue mutually beneficial collaborations, and leverage opportunities for effective technology transition. AAVP directly supports three of the ARMD Strategic Thrusts (Thrust 2: Innovation in Commercial Supersonic Aircraft, Thrust 3: Ultra-efficient Commercial Vehicles, and Thrust 4: Transition to Low-Carbon Propulsion).

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017

- Complete preparations to test a superconducting motor that is a key component for some electrified aviation propulsion architectures that may lead to significant reduction in carbon emissions.
- Complete Low Boom Flight Demonstrator (LBFD) preliminary design.
- Test a revolutionary engine inlet-fan configuration that is a key enabler for some future concepts.
- Initiate Phase II of the Advanced Composites (AC) Project.
- Demonstrate a two-speed transmission drive system for vertical lift vehicles.
- Complete design and initiate installation of new acoustical treatment in the GRC 9x15-Foot Low Speed Wind Tunnel.
- Initiate a new effort to reduce the uncertainty in hypersonic vehicle design computational tools, ground testing, and flight experimentation.

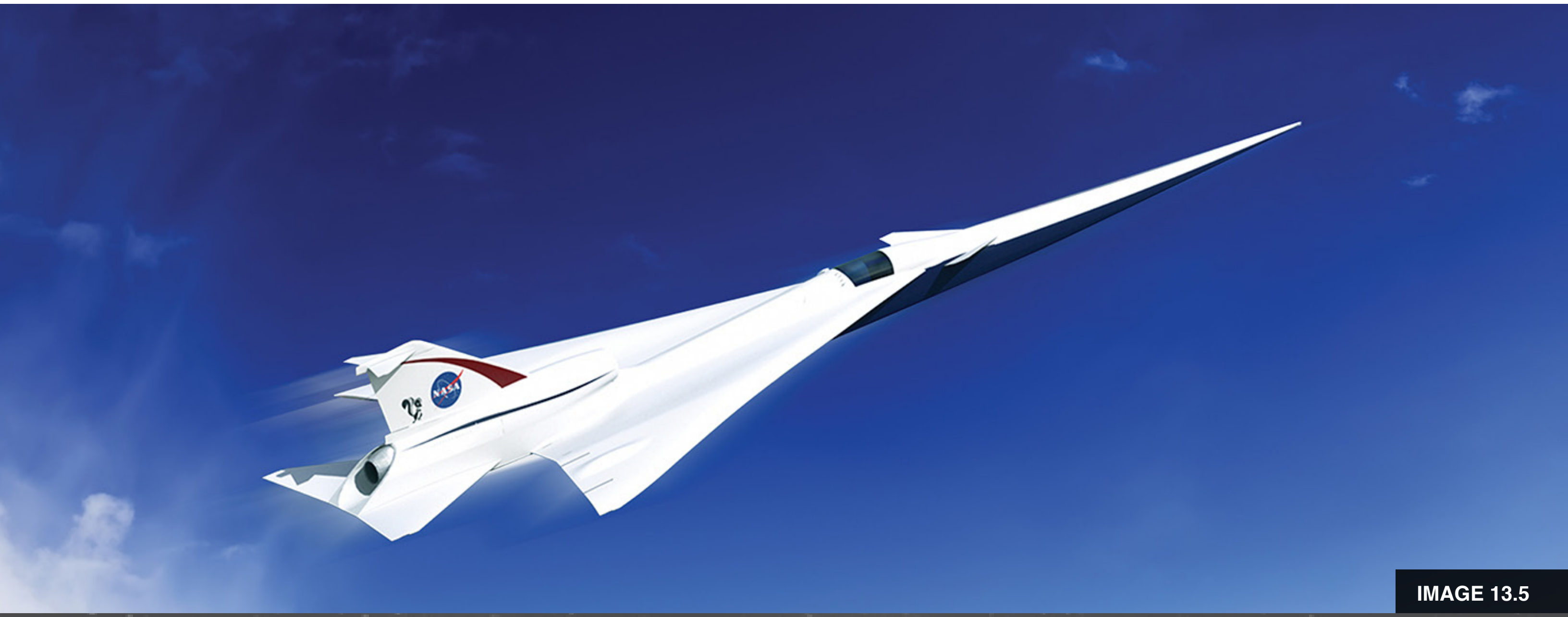


IMAGE 13.5

PROGRAMS

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2018 – FY 2020

- Reduce fan (lateral and flyover) and high-lift system (approach) noise on a component basis by 4 decibel with minimal impact on weight and performance.
- Complete installation of new acoustical treatment in the GRC 9x15-Foot Low Speed Wind Tunnel to reduce the facility background noise to levels that enable testing of next-generation low noise propulsion system concepts.
- Validate field study methodology, including indoor and outdoor noise metrics, exposure estimates, survey tools, and test protocols to support community studies with a low-boom flight demonstration aircraft.
- Develop Computational tools to reliably predict strength and life of composite structures, in order to reduce design cycle time and testing effort by 30% during development and certification.
- Enable a 1.5-2X increase in the aspect ratio of a lightweight wing with safe structures and flight control.
- Reduce Nitrogen oxide (NOx) emissions from fuel-flexible combustors to 80% below the CAEP/6 standard with minimal impacts on weight, noise, or component life.
- Establish viable concept for 5-10 megawatt hybrid gas-electric propulsion system for a commercial transport aircraft.
- Combine improved flight operations, a high-fidelity rotor/vehicle design approach, and human factors research to provide a 50% reduction in Sound Exposure Level (SEL) footprint area for commercial VTOL vehicles in common use.
- Enable reduced size/flow high-pressure compressors and high temperature disk/seals that are critical for 50+ Overall Pressure Ration (OPR) gas generators with minimal impact on noise and component life.

PARTNER OVERVIEW

- **NASA Center(s):** Glenn Research Center, Ames Research Center, Armstrong Flight Research Center, Langley Research Center
- **Federal Agencies:** U.S. Air Force, U.S. Navy, U.S. Army, DoD
- **Academia:** Multiple universities in related research
- **Industry:** Boeing, Pratt & Whitney, Northrop, Grumman, General Electric Aviation, Aurora, United Technologies Corporation, Rolls Royce/Liberty Works, Honeywell, Lockheed Martin, Gulfstream Aerospace, Rockwell Collins, KTH, Sweden, Aerion Corporation, U.S. small businesses, UTRC GE, Pratt and Whitney, Joby Aviation, European High Altitude Ice Crystal (HAIC) Consortium, SEA Inc.

IMAGE 13.6

INTEGRATED AVIATION SYSTEMS PROGRAM

PROGRAM WEBSITE - *http://www.aeronautics.nasa.gov/programs-iasp.htm*

SHORT DESCRIPTION

The Integrated Aviation Systems Program (IASP) addresses one of the key issues that NASA faces, bridging the gap between the maturity levels of technologies developed through fundamental research and the technology maturity requirement for infusion of advanced technologies into future air vehicles and operational systems. The goal of IASP is to demonstrate integrated concepts and technologies in a relevant environment at a maturity level sufficient to reduce risk of implementation in the aviation community. IASP focuses on the rigorous execution of highly complex flight tests and related experiments. These flight tests support all phases of ARMD research, not just the culmination of research activities reducing risks and accelerating transition of technologies to industry.

IASP also addresses the national challenge of reducing the barriers toward routine access of UAS into the NAS for civil use. The FAA is developing new policies, procedures, and approval processes to address the increasing civil market opportunities and the desire of civilian operation of UAS in the NAS on a routine basis. NASA's UAS Integration in the NAS Project will contribute flight-validated technologies and capabilities that reduce technical barriers related to safety and operational challenges associated with enabling routine civil UAS access to the NAS.
IASP directly supports three of the ARMD Strategic Thrusts (Thrust 2: Innovation in Commercial Supersonic Aircraft, Thrust 3: Ultra-Efficient Commercial Vehicles, and Thrust 6: Assured Autonomy for Aviation Transformation).

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017

- Award contract for design/build phase of the new LBFD Project as part of the bold NAH initiative that will support a continuing series of transformative experimental vehicles and systems.
- Contract award for Preliminary Design Review of a flight demonstration to validate technologies to improve the performance of Ultra-High Bypass Engine Nacelles.
- Collaboration with Aurora Flight Sciences to reduce the aircraft environmental footprint to assess the D8 configuration.
- Complete the Adaptive Compliant Trailing Edge (ACTE) II Noise Reduction Flight experiment.
- Award contract to commence with preliminary design activities for the Ultra-Efficient Subsonic Demonstrator (UESD) that will lead to completion of Preliminary Design Review (PDR) in FY 2018.
- Extend the UAS in the NAS project through FY 2020 to support the FAA and the Radio Technical Commission for Aeronautics (RTCA) Special Committee-228 in the development of Phase 2 Minimum Operational Performance Standards (MOPS).

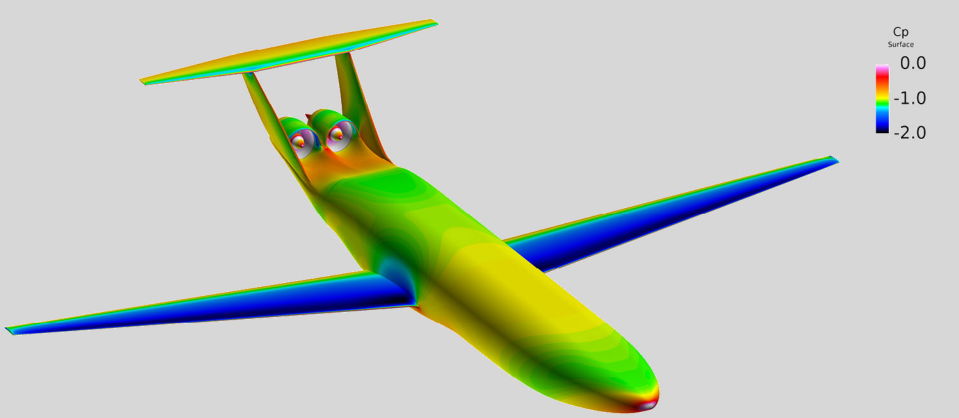


IMAGE 13.7

PROGRAMS

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2018 – FY 2020

- Demonstrate novel landing gear porous fairing and wheel cavity treatments that reduce the airframe component of community noise by 1.5 decibel.
- Demonstrate advanced nacelle technologies to mitigate the performance losses attributed to the increased nacelle diameter of ultra-high bypass engines, achieving a 1.5% fuel burn reduction.
- Develop DAA Minimum Operational Performance Standards for Routine UAS Operations.
- Develop SATCOM Minimum Operational Performance Standards for UAS Operations in the NAS.
- Integrated Test and Evaluation of critical technologies supporting routine UAS operations in the NAS.

PARTNER OVERVIEW

- **NASA Center(s):** Ames Research Center, Armstrong Flight Research Center, Glenn Research Center, Langley Research Center
- **Federal Agencies:** FAA, DoD, Air Force Research Laboratory
- **Academia:** University of North Dakota
- **Industry:** Rockwell Collins, Dragonfly Pictures, General Atomics, Lockheed Martin, FlexSys, Aurora Flight Sciences, Pratt & Whitney

IMAGE 13.8

TRANSFORMATIVE AERONAUTICS CONCEPTS PROGRAM

PROGRAM WEBSITE - *http://www.aeronautics.nasa.gov/programs-tacp.htm*

SHORT DESCRIPTION

The Transformative Aeronautics Program (TACP) cultivates multi-disciplinary, revolutionary concepts to enable aviation transformation. ARMD's strategic analysis identified challenges in the global demand for mobility, significant energy and sustainability challenges, and ongoing affordability issues, for which technology can be a key part of the solutions. TACP fosters innovative solutions to these problems, capitalizing on advancements in aeronautics and non-aeronautics sectors to create new opportunities in aviation. The ultimate goal of the program is to knock down technical barriers and infuse internally and externally originated concepts into all six ARMD strategic thrusts, creating innovation for tomorrow in the aviation system.

Using sharply focused activities, the program provides flexibility for innovators to explore technology feasibility and provide the knowledge base for radical transformation. The program solicits and encourages revolutionary concepts, creates the environment for researchers to become immersed in trying out new ideas, performs ground and small-scale flight tests, allows failures and learns from them, and drives rapid turnover into new concepts. Further, TACP places attention on computational and experimental tools that are critical for supporting development and enabling aviation transformation. Thereby, investments are in unprecedented developments that can provide paradigm-shifting analysis and experimental capability. All of this research is done while proactively engaging the traditional aeronautics community as well as non-traditional partners.

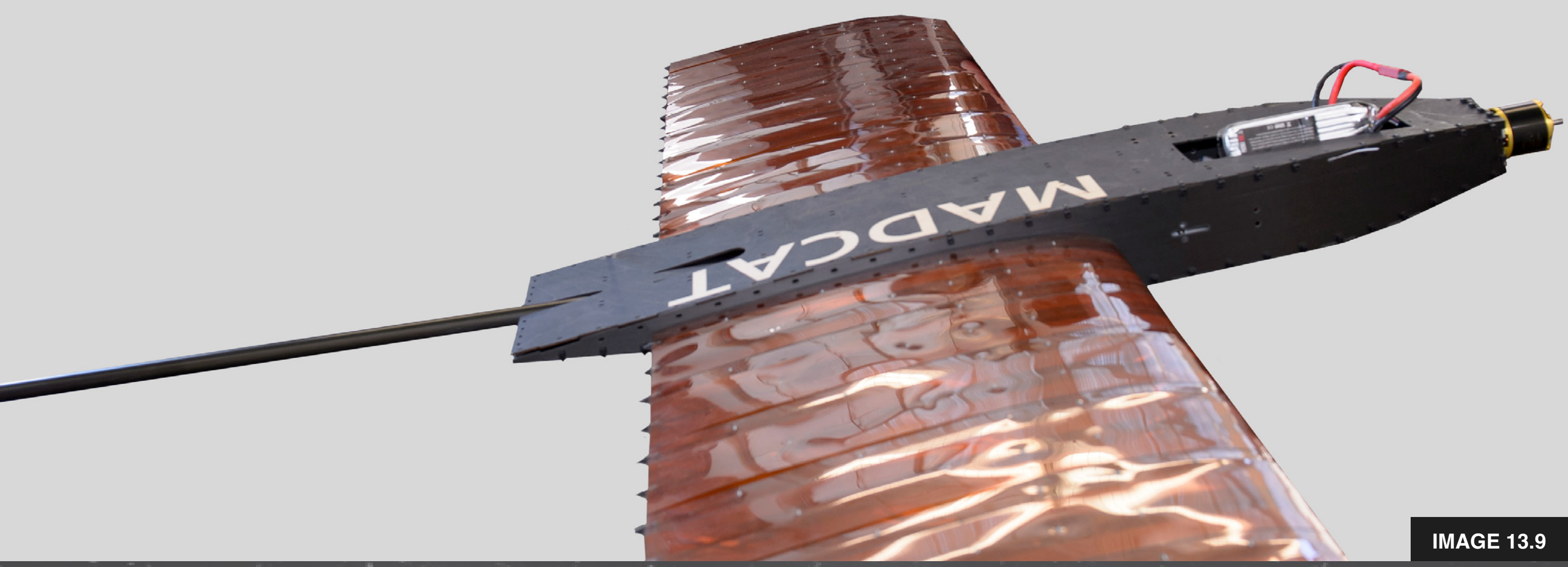


IMAGE 13.9

PROGRAMS

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017

- Demonstrate critical turbulence models and numerical methods for separated flows that provide a 40% reduction in predictive error against standard test cases in the Transformational Tools and Technologies (TTT) Project.
- Develop high-temperature material systems for turbine engine components that enable a 6% reduction in fuel burn while meeting 2700° Fahrenheit operational use temperature and durability metrics.
- Complete feasibility assessments for several activities within the Convergent Aeronautics Solutions (CAS) Project
- Evaluate the feasibility of a set of “smart apps” for autonomous UAS in flight.
- Complete feasibility assessment of an innovative aircraft design and build concept that merges digital manufacturing, lightweight materials, and novel flight control techniques.
- Begin a new round of investments in early-stage, multi-disciplinary concept research and technology feasibility experiments performed by NASA researchers within the CAS Project.
- Make initial University Leadership Initiative awards in the University Innovation and Challenges (UIC) Project to university-led teams for independent, multidisciplinary research projects focused on the ARMD strategic outcomes.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2018 – FY 2020

- Demonstrate capability to predict sensitivity of combustor efficiency, emissions, and operability to changes in fuel composition.
- Integrate aero, propulsion, acoustic, and structural Multi-Disciplinary Analysis and Optimization (MDAO) tools with multi-fidelity concept assessment tools to enable multi-to-high fidelity optimization of the latest ARMD concept configurations.

PARTNER OVERVIEW

- **NASA Center(s):** Ames Research Center, Glenn Research Center, Langley Research Center, Armstrong Flight Research Center
- **Federal Agencies:** Air Force Research Laboratory (AFRL), Wright-Patterson Air Force Base (WP AFB), FAA, U.S. Air Force, U.S. Army, U.S. Navy, Defense Advanced Research Projects Agency (DARPA)
- **Academia:** Ohio Aerospace Institute
- **Industry:** JOBY Aviation, PCKrause & Associates, National Institute of Aerospace, Boeing, ESAero, Tecnam MTProp, Launch Point, Cape Air, Straight Up Imaging, DoT Volpe, Moog Inc., IDEO, Idea Couture, Tecolote Research Inc., Pratt & Whitney, Rolls Royce, Honda, UTRC, ESI, Blue Quartz Software, General Electric, Distributed Engine Controls Working Group Consortium, Honeywell, BAE Systems, UTC Aerospace Systems, U.S. small businesses

IMAGE 13.10

APPROACH TO MISSIONS

NASA is developing capabilities to move human presence into the solar system—advancing through Earth Reliant, Proving Ground and Earth Independent regimes. The Human Exploration and Operations Mission Directorate (HEOMD) is responsible for the overall effort of managing human spaceflight activities for NASA.

Earth Reliant operations begin with ISS as a test bed for long-duration spaceflight research and technology development. We are enabling private sector demand for research in low Earth orbit (LEO), which provides benefits to people on Earth. HEOMD has partnered with private firms to successfully send and return cargo to ISS, and is now partnering to develop vehicles to safely fly humans to LEO. This enables the private sector “supply side” to be ready to support emerging private sector “demand” - with decreasing direct involvement from the government.

HEOMD is developing NASA’s next generation launch systems and crew vehicle to go to cislunar space—the region from the Earth and around the Moon. NASA will use this region as a Proving Ground—to test and validate new spaceflight systems. SLS and Orion also open up other scientific and technology opportunities. These same systems are required to conduct Mars-class missions and Earth Independent human spaceflight. As part of the proving ground activities, NASA will conduct a crewed sample return mission from an asteroid boulder in ~ 2026, with the robotic portion of boulder acquisition launching in 2021. Also as part of the Proving Ground activity, habitation systems needed for Mars-class missions are being developed. The Proving Ground phase will conclude with a full duration Mars-class mission simulation.

Earth Independent human missions to Mars will utilize Orion (including the ESA-provided Service Module), an evolved version of SLS, deep space habitation, and in-space propulsion. This approach allows NASA to conduct human operations in the vicinity of Mars in the early 2030s at roughly current budget levels with inflation.

As NASA expands human presence from LEO to deeper in the solar system, HEOMD invests in the new technologies and systems astronauts will need on the journey to Mars and provides and plans for current and future launch and space communication and navigation services for crewed and robotic missions, and ensures availability of rocket test stands across the Agency.

APPROACH TO MISSIONS

HIGHLIGHTS OF 2016 ACHIEVEMENTS

DEVELOPING THE EXPLORATION VEHICLES TO EXTEND HUMAN PRESENCE INTO THE SOLAR SYSTEM

- Delivered Exploration Mission (EM)-1's Orion pressure vessel to KSC and began assembly operations.
- Completed welding the Space Launch System (SLS) core stage with the Vertical Assembly Center at MAF.
- Completed SLS booster qualification motor test program and began casting EM-1 flight article solid rocket motor segments.
- Prepared for SLS ground processing at KSC continuing to install Vehicle Assembly Building platforms, fabricate Mobile Launcher umbilical, and refurbish the Crawler Transporter.
- Awarded public-private partnerships with six companies through Next Space Technologies for Exploration Partnerships (NextSTEP) Broad Area Announcements to begin development of deep space habitation systems that will also have applications for commercial habitats in low Earth orbit.
- Completed Phase 1 designs for the Asteroid Redirect Mission robotic spacecraft through four companies to leverage commercial capabilities and facilitate future commercial capabilities. Released Broad Area Announcement soliciting partnerships for hosted payloads and an Investigation Team.

USING THE ISS TO PREPARE FOR HUMAN DEEP SPACE EXPLORATION AND CONDUCT RESEARCH

- Installed IDA-2 docking ports on ISS for commercial crew vehicles.
- Successfully deployed Bigelow Expandable Activity Module on ISS demonstrating inflatable technology in space environment.
- Concluded one-year U.S./Russian mission to investigate effects of long-term spaceflight on the human body through ISS, HRP and Crew Health and Safety collaboration.
- Used ISS as microgravity platform for 317 experiments in collaboration with 29 different countries including commercial companies.
- NASA completed the Independent Review Team (IRT) activities for the Orb-3 Antares 130 launch failure.

ADVANCING U.S. COMMERCIAL SPACE TRANSPORTATION

- SpaceX and Orbital ATK launched five successful cargo resupply missions to ISS.
- Awarded three additional commercial cargo contracts and one new provider (Sierra Nevada) in addition to previous providers (SpaceX and Orbital ATK)—each providing unique cargo capability to and from ISS.
- Began training astronauts to support first human commercial space vehicles to ISS with crew assignments to Commercial Crew demo/test missions later this year.
- Boeing and SpaceX accomplished key milestones in crewed vehicle development and began work on Post Certification Missions—2 each to Boeing and Space—for operational crew transportation missions to the ISS.

PROVIDING EFFECTIVE SPACE COMMUNICATIONS, LAUNCH SERVICES, ROCKET PROPULSION TESTS, AND HUMAN SPACEFLIGHT SUPPORT SERVICES TO OTHER NASA PROGRAMS

- LSP completed NASA IRT activities for SpX-7 Falcon 9 failure, and then successfully launched the NOAA Jason-3 mission on January 17th 2016. LSP is currently the designated Agency lead participating in the SpaceX Accident Investigation Team for the Sep 1st 2016 propellant loading test failure.
- LSP managed the successful commercial launch services with United Launch Alliance (ULA) for the September 8th launch of the Science Mission Directorate's (SMD's) OSIRIS-REx mission, and awarded a launch service task order to ULA for SMD's Mars 2020 mission.
- SCaN completed a successful 2015 World Radio Communication conference in Geneva resulting in the approval of U.S. proposals on Spectrum issues.
- Consolidated and maintained NASA's Rocket propulsion test facilities for the Agency.
- Provided space communication services for the Agency and began upgrading the Tracking and Data Relay Satellite Systems ground site at White Sands Test Facility.

PROGRAMS

INTERNATIONAL SPACE STATION

PROGRAM WEBSITE *- http://www.nasa.gov/mission_pages/station/main/index.html*

SHORT DESCRIPTION

The International Space Station (ISS) is a complex research facility and human outpost in low Earth orbit (LEO) developed and led by the U.S with partners in Canada, Europe, Japan, and Russia to advance exploration of the solar system, enable unique scientific research, and promote commerce in space. With an international permanent crew of six, ISS is approximately the size of a five-bedroom house and covers the length of a football field with the wingspan longer than that of a Boeing 777. There are four major focus areas of activity in the ISS Program:

Research onboard ISS helps return benefits to humanity on Earth. As a National Laboratory, ISS enables partners in government, academia, and private industry to utilize its unique environment and advanced facilities to perform investigations in a wide variety of disciplines such as pharmaceuticals, biotechnology, material and physical sciences, astrophysics, Earth sciences, satellite technology, robotic spacecraft repair, as well as human health. The results of research completed on ISS can be applied to many areas of science, improving life on this planet, and furthering the experience and increased understanding necessary to journey to other worlds.

ISS is a key stepping stone on the journey to Mars—it is the only microgravity platform for long-term testing of new life support and crew health systems, advanced habitat modules, and other technologies needed to decrease reliance on Earth. The facility enables scientists to identify and quantify risks to human health and performance, and to develop and test countermeasures and technologies to protect astronauts during extended human space exploration.

ISS is a key enabler of the development of a commercial marketplace in LEO. NASA and the ISS Program, in partnership with the Center for the Advancement of Science in Space (CASIS), are leveraging ISS to reach broad sectors of traditional and non-traditional commercial companies, as well as other government agencies to utilize the ISS National Laboratory and stimulate demand for ongoing commercial activity in LEO.

Finally, NASA's leadership of the ISS Program helps maintain U.S. leadership of space exploration as a whole. The Administration and Congress have both endorsed extending the life of the ISS through at least 2024, providing nearly another decade for critical research and to allow more time for the LEO commercial market to mature. Following this leadership, Canada, Japan, and Russia have also announced plans to continue supporting ISS through at least 2024 (European confirmation of support is expected in late 2016). NASA is beginning to leverage the strong ISS international partnership to plan its human space flight transition beyond LEO including joint architecture studies and cooperative technology development efforts.

IMAGE 13.11

PROGRAMS

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017

- Four crew rotation flights via Soyuz and seven cargo flights via U.S commercial cargo providers and four cargo flight via Russian Progress and Japanese HTV.
- Advance model organism research critical to future human exploration of space through first Joint U.S./Russian Rodent Research Investigation.
- Launch Advanced Plant Habitat and execute the first science mission, APEX-05, to advance plant research in space to support deep space human exploration.
- Begin GeneLab Data System Phase 2 and release Innovation NASA Research Announcement selections, advancing "omics" research for human exploration of space with application for life on Earth.
- Launch the Cold Atom Laboratory, which will use the microgravity environment of the ISS to create the coldest matter in the observable universe. A science team that includes three Nobel laureates will conduct experiments exploring the potential of this new realm of atomic physics to contribute to leading edge research like gravity wave and dark energy detection.
- Launch and complete operations of combustion research investigations, Cool Flames Investigation a joint U.S./ Russian experiment and the Advance Combustion Microgravity Experiment.
- Demonstrate new solar array systems technology through Roll-Out Solar Array.
- Demonstrate new technology to recover additional water from urine.
- Launch new Earth sensing and space science experiments, including Multi-User System for Earth Sensing, Cosmic Ray Energetics and Mass, Stratospheric Aerosol and Gas Experiment, Neutron Star Interior Composition Explorer and Total and Spectral solar Irradiance Sensor.
- Perform anomaly resolution and failure investigation as needed, and provide real-time support for activities, such as EVA and visiting vehicles. Four U.S. EVAs are tentatively planned for FY 2017, three in FY 2018, six in FY 2019 and six in FY 2020.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2018 – FY 2020

- Conduct first commercial crewed flights to ISS by Boeing and SpaceX.
- Five crew rotation flights via U.S. commercial crew providers, nine crew rotation flights via Soyuz and 26 cargo flights via Russian Progress, Japanese HTV, and U.S commercial cargo providers.
- Make NASA Research Announcement selections in Space Biology and awards in Physical Science Informatics bringing in new research to advance human exploration of space and for application for life on Earth.
- Conduct cell science investigations advancing human exploration of space and leading to advancements to improve life on Earth.
- Continue ISS demonstrations for exploration habitation systems, including environmental control and life support system, fire safety, and crew health.

PARTNER OVERVIEW

- **NASA Center(s):** Ames Research Center (ARC), Glenn Research Center (GRC), Goddard Space Flight Center (GSFC)—Wallops Flight Facility, Jet Propulsion Laboratory—Federally Funded Research and Development Center (FFRDC), Johnson Space Center (JSC), Kennedy Space Center (KSC), Marshall Space Flight Center (MSFC)
- **Federal Agencies:** Federal Aviation Administration (FAA), Defense Advanced Research Projects Agency (DARPA)
- **International:** ISS International Partners: Canada, European Space Agency, Japan, and Russia
- **Academia:** N/A
- **Industry:** Center for the Advancement of Science in Space, COLSA Corporation, Orbital-ATK, Sierra Nevada, SpaceX, Teledyne Brown Engineering, The Boeing Company

PROGRAMS

COMMERCIAL CREW PROGRAM

PROGRAM WEBSITE - *http://www.nasa.gov/exploration/commercial/crew/index.html*

SHORT DESCRIPTION

NASA's Commercial Crew Program (CCP) facilitates development of a U.S. commercial crew space transportation capability by investing in multiple American companies that are designing and developing transportation capabilities to and from low Earth orbit (LEO) and the International Space Station (ISS). NASA's goal is achieving safe, reliable and cost-effective access to and from ISS and LEO. By supporting development of human spaceflight capabilities, NASA is laying the foundation for future commercial human space transportation capabilities turning over LEO so NASA can move to deep space exploration.

Throughout the process, both NASA and industry have invested time, money, and resources in the development of their systems. NASA also is spurring economic growth through this program as potential new space markets are created. With over 350 American companies across 36 states working toward this goal, there are significant economic benefits to returning these launches to American soil. NASA projects that the average seat price will be $58 million per seat for Commercial Crew. The currently contracted Soyuz price for 2018 is approximately $82 million per seat. U.S. commercial crew capabilities will enable the Station crew to be expanded from six to seven astronauts and cosmonauts, resulting in a doubling of on-orbit research time to almost 80 hours per week. This is because the seventh crew member will be able to focus his or her time almost exclusively on conducting experiments, rather than on Station operations and maintenance.

NASA awarded two Commercial Crew transportation Capability contracts, one with Boeing for $4.2 billion, and one with SpaceX for $2.6 billion, for a total maximum value of $6.8 billion. The contract scope of both contracts is the same, but prices are difference because of differences in launch vehicles, development, operational and management approaches. The contract scope includes the final developmental activities and six Post Certification Missions per company to the ISS. These spacecraft also will serve as a lifeboat for astronauts aboard the ISS. If all 12 post certification missions are flown, these contracts can support the ISS crew transportation needs into 2023.

In addition, the Commercial Spaceflight Development Division at NASA HQ also manages other collaborative activities with industry to develop new commercial capabilities, such as the Red Dragon mission to Mars with SpaceX, enhanced propulsion technologies with United Launch Alliance, and new commercial space suit design with Final Frontier Design.

IMAGE 13.12

PROGRAMS

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017

- Complete Boeing Service Module Hot Fire Launch Abort Test.
- Complete SpaceX ISS Design Certification Review.
- Conduct SpaceX Demo Mission 1—flight to ISS without crew.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2018 – FY 2020

- Complete Boeing Pad Abort Test.
- Complete Boeing ISS Design Certification Review.
- Conduct Boeing Orbital Flight Test.
- Conduct Boeing Crewed Flight Test.
- Conclude Boeing Certification Review (final development milestone).
- Conduct SpaceX Demo Mission 2--Flight to ISS with Crew.
- Conclude SpaceX Certification Review (final development milestone).
- Starting in FY 2018, Boeing and SpaceX will begin their operational missions to ISS.

PARTNER OVERVIEW

- **NASA Center(s):** KSC, JSC, support from most other NASA centers
- **Federal Agencies:** FAA
- **International:** N/A
- **Academia:** N/A
- **Industry:** Fixed price, milestone based contracts with SpaceX and The Boeing Company; unfunded Space Act Agreement with Blue Origin

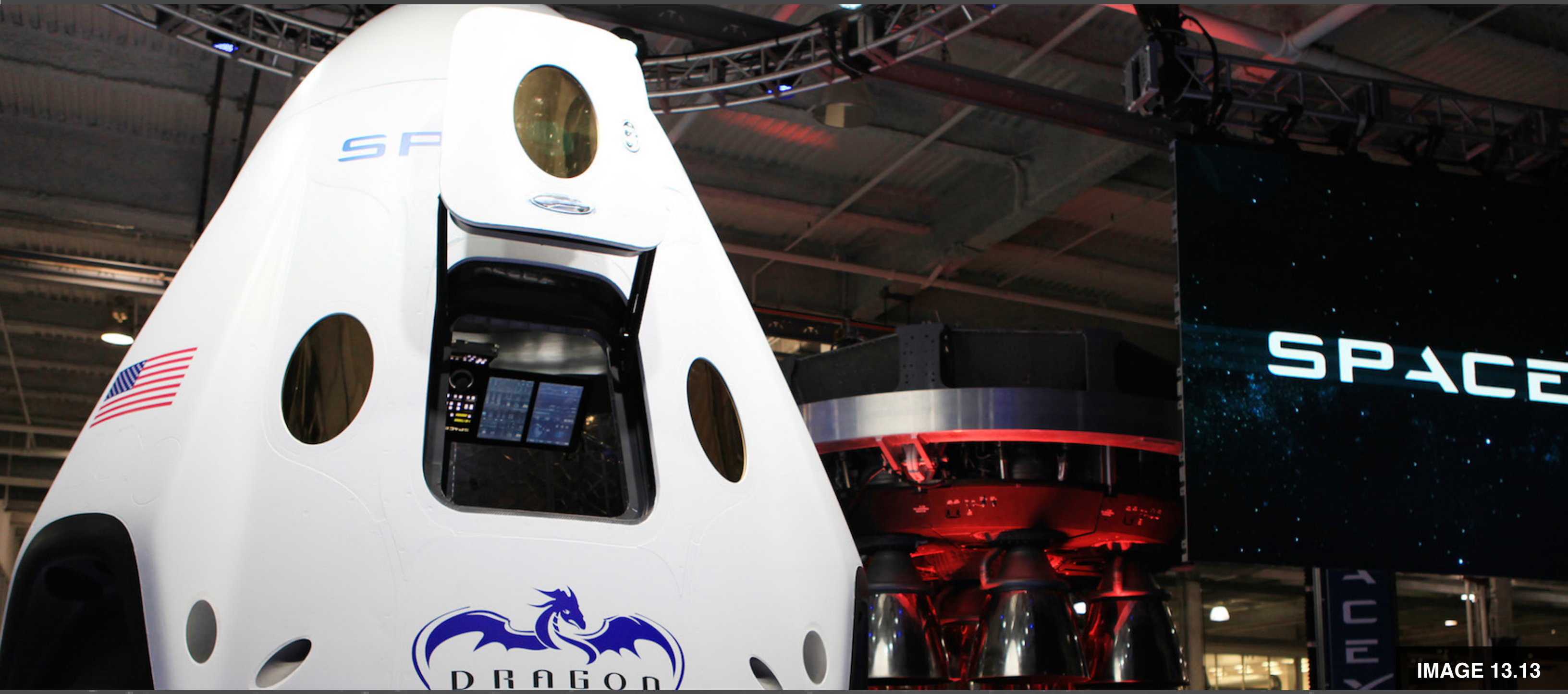


IMAGE 13.13

PROGRAMS

EXPLORATION SYSTEMS DEVELOPMENT

SLS PROGRAM WEBSITE - *http://www.nasa.gov/exploration/systems/sls/index.html*
ORION PROGRAM WEBSITE - *http://www.nasa.gov/exploration/systems/orion/index.html*
GSDO PROGRAM WEBSITE - *http://www.nasa.gov/exploration/systems/ground/index.html*

SHORT DESCRIPTION

NASA is working to expand human presence into the solar system, including eventually to the surface of Mars. Exploring deep space requires the capability to transport crew and large masses of cargo beyond low Earth orbit. To accomplish this exploration theme, HEOMD's Exploration Systems Development (ESD) Enterprise is responsible for developing and integrating a crew capsule, heavy-lift launch vehicle, and supporting ground facilities and systems that can evolve over time to meet various exploration missions for the Agency.

Within the ESD Enterprise, three programs are developing the core capabilities required to implement NASA's multi-destination strategy. The Space Launch System (SLS) program is developing the heavy-lift vehicle that will launch the crew vehicle, other modules, and cargo for deep space missions.

The Orion program is developing the space vehicle that will carry the crew to orbit, provide emergency abort capability, sustain the crew while in space, and provide safe reentry from deep space return speeds.

The Exploration Ground Systems program is developing the launch site infrastructure to prepare, assemble, test, launch, and recover SLS and Orion flight systems. NASA Headquarters integrates these programs to streamline decision-making processes, and enable an affordable long-term human exploration program.

NASA will first demonstrate this exploration capability on Exploration Mission 1 (EM-1), an uncrewed test flight of SLS and Orion around the Moon. EM-1 is planned for launch in late 2018. Targeted for launch in 2021 is EM-2, the first mission with crew and an upgraded SLS "Block 1B". The Block 1B upgrade (with a four-engine Exploration Upper Stage and a Universal Stage Adaptor) will ensure SLS is capable of carrying large co-manifested payloads along with Orion to cislunar space, enabling complex missions in the Proving Ground that will pave the way for flights to Mars.

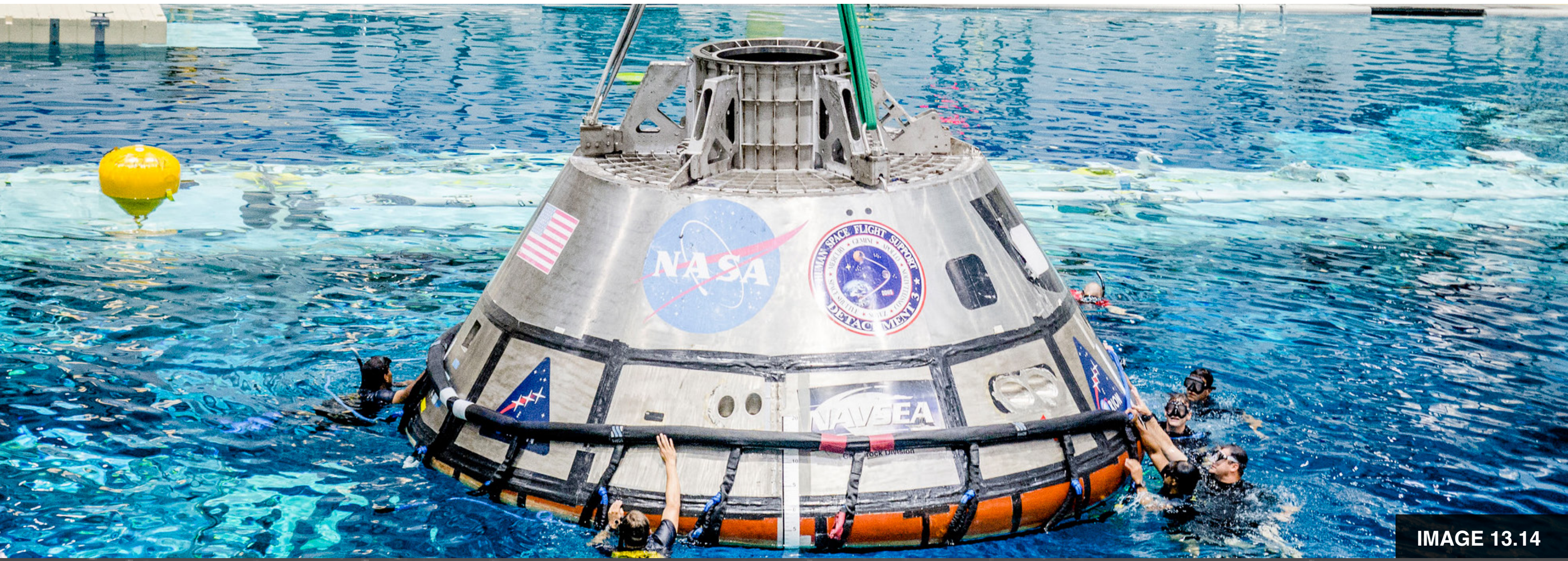


IMAGE 13.14

PROGRAMS

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017

- Complete Launch Complex 39 Pad B construction, complete Vehicle Assembly Building (VAB) platforms and VAB/Mobile Launcher integrated verification and validation, and complete spacecraft command and control software for integrated operations in preparation for EM-1 launch operations.
- Begin Orion structural test article mate and testing, install Orion's Crew Module heat shield, and deliver European Space Agency provided Service Module to KSC and mate to Crew Module.
- Finish delivery of four RS-25 SLS core stage flight engines to Michoud Assembly Facility, complete production of Interim Cryogenic Propulsion System (ICPS), deliver all booster solid rocket motor segments to KSC, and ship flight core stage to Stennis Space Center for testing in preparation for EM-1.
- Start manufacturing EM-2 Crew Module pressure vessel.
- Conduct preliminary design reviews for Exploration Upper Stage, Universal Stage Adaptor, and Payload Adaptor Fixture required for EM-2 and to ensure SLS is capable of carrying large co-manifested payloads along with Orion to cislunar space.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2018 – FY 2020

- Perform integrated testing of the Crew Service Module (CSM) flight article at Plum Brook Station (PBS), Ohio and deliver CSM to KSC for stacking on SLS.
- Deliver core stage, ICPS, and Orion and launch vehicle stage adaptors to KSC to begin stacking.
- Conduct integration and flight readiness reviews, integrated stack testing, and rollout for launch.
- Launch EM-1 no later than November 2018.

PARTNER OVERVIEW

- **NASA Center(s):** ARC, GRC, KSC, LaRC, MSFC,
- **Federal Agencies:** N/A
- **International:** European Space Agency
- **Academia:** N/A
- **Industry:** Aerojet Rocketdyne, J.P. Donovan Construction, Inc., Hensel Phelps Construction, Inc., Lockheed Martin, Orbital ATK, The Boeing Company

IMAGE 13.15

PROGRAMS

ASTEROID REDIRECT MISSION

PROGRAM WEBSITE - *https://www.nasa.gov/mission_pages/asteroids/initiative/index.html*

SHORT DESCRIPTION

ARM provides an integrated capability demonstration for a number of systems, each important in its own right, to accomplish a range of objectives. An early mission in the proving ground of cis-lunar space, ARM human space flight demonstration objectives are an important early step to longer term crew activities in deep space. There are three main segments to ARM:

- Target Asteroid Identification: Near-Earth Object Observations in NASA's Science Mission Directorate is already identifying and characterizing candidate asteroids through ground and space-based assets.
- Asteroid Redirect Robotic Mission (ARRM) will perform an asteroid deflection demonstration and ferry a multi-ton asteroid boulder to cis-lunar space via a solar-electric propulsion (SEP) based system.
- Asteroid Redirect Crewed Mission (ARCM), planned for the mid-2020s, will explore the multi-ton asteroid mass with crew via a SLS rocket and Orion spacecraft and return samples to Earth.

ARM will provide key contributions of space flight technologies and operational experience needed for NASA's journey to Mars, including transporting multi-ton objects with advanced solar electric propulsion, integrating crewed/robotic vehicle operations in deep space staging orbits, utilizing advanced autonomous proximity operations and rendezvous in deep space and with non-cooperative objects, conducting astronaut EVAs for sample selection, extraction, and containment, and strategies for emergency return of the crew.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017

- To support Dec 2021 launch date, award ARRM spacecraft design contract, with option for development.
- Award ARM competitive selections for partnerships for Hosted Payloads for robotic mission and ARM Investigation Team.
- Conduct electric propulsion system preliminary design review.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2018 – FY 2020

- Maintain ARRM ongoing technology flight development.
- Complete ARRM spacecraft design and development, and begin integration and test.
- Finalize formal agreements for international partnerships on robotic mission.
- Conduct ARRM Preliminary Design Review.
- Complete ARRM Key Decision Point -C for approval for implementation and to set the Agency's external commitments for the mission.
- Continue crewed mission pre-formulation and deliver support hardware for the crewed mission, such as rendezvous sensors, to ARRM.

PARTNER OVERVIEW

- **NASA Centers:** ARC, GRC, GSFC, JPL-FFRDC, JSC, LaRC
- **Federal Agencies:** Potentially USGS
- **International:** Italian Space Agency and potentially the Canadian and Japanese Space Agencies
- **Academia:** competitions for partnerships in hosted payloads and the investigation team are open now, with selections in March 2017
- **Industry:** competitions for partnerships in hosted payloads, the investigation team, and for the spacecraft bus are open now, with selections in March 2017

PROGRAMS

ADVANCED EXPLORATION SYSTEMS

PROGRAM WEBSITE - *https://www.nasa.gov/directorates/heo/aes/index.html*

SHORT DESCRIPTION

AES develops foundational technologies and high-priority capabilities for future human missions using an approach that combines focused, in-house activities with public-private partnerships to develop and test prototype systems. AES is pioneering ways to drive a rapid pace of progress, streamline management, foster partnerships with external organizations, and more effectively utilize the NASA workforce as we transition to enabling human space flight beyond low Earth orbit.

NASA-led teams of engineers and technologists across the country are engaged in systems development activities, demonstrating key capabilities in-flight or flight-like environments, validating operational concepts, gaining valuable hands-on experience with hardware, and mastering the skills necessary for future human spaceflight. By performing early validation and testing of prototype systems, NASA is able to reduce risk and improve the affordability of future space exploration.

AES activities focus on human space flight systems for deep space and robotic precursor missions to identify and fill in knowledge gaps related to potential destinations for human exploration. Major areas of work include systems development for more reliable life support, deep space habitation technology, advanced in-space propulsion, landing capabilities, *in situ* resource prospecting and processing, and overall capabilities to reduce logistics requirements to support future human missions. These efforts will enable human space flight to become increasingly Earth-independent and capable of expanding into the solar system.

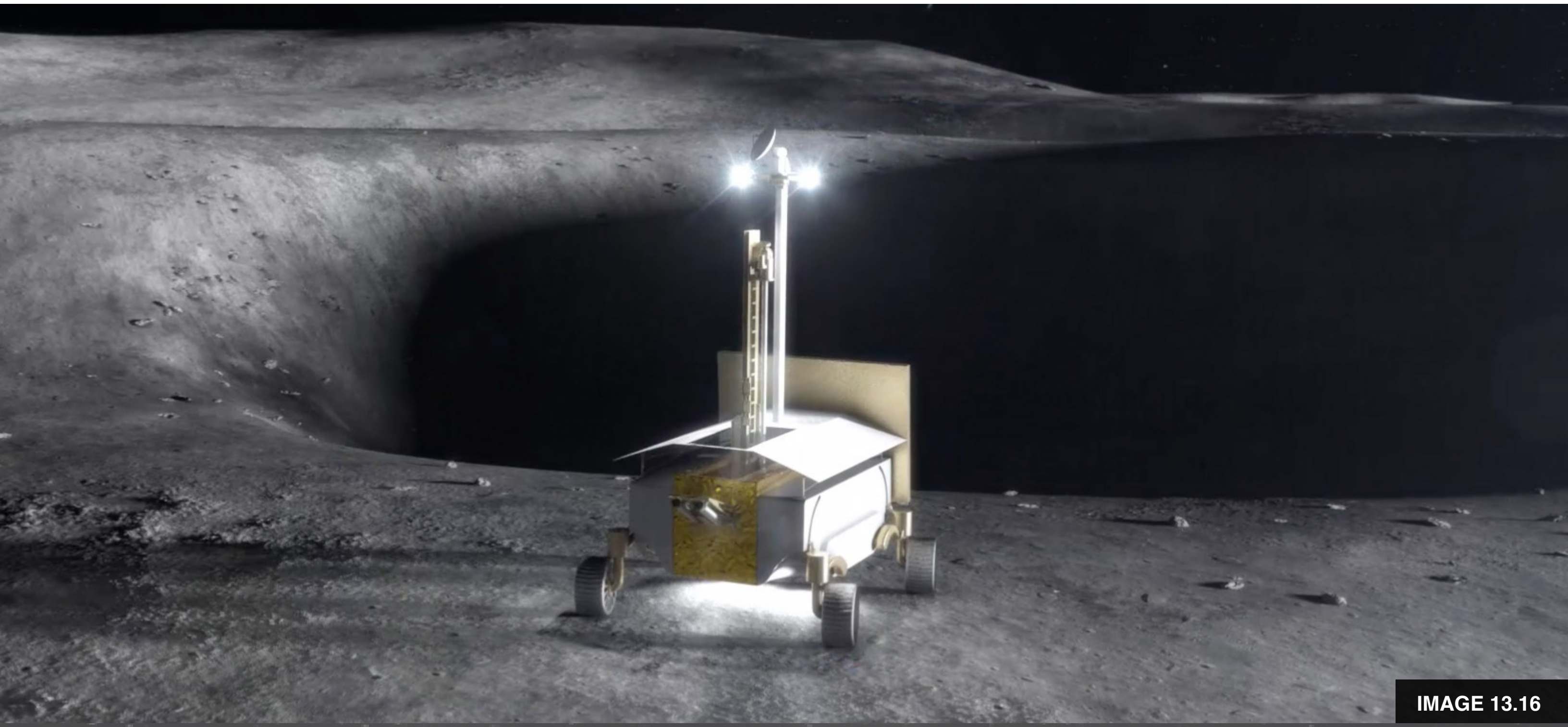


IMAGE 13.16

PROGRAMS

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017

- Complete Critical Design Review for Mars Oxygen *in situ* Resource Utilization Experiment (MOXIE) that will demonstrate the production of oxygen from the Martian atmosphere on the Mars 2020 mission.
- Conduct Navigation Doppler Lidar flight test to enable autonomous precision landing on the Moon and Mars.
- Complete Critical Design Review of the Ascent Abort-2 flight test of the Orion launch abort system.
- Demonstrate combustion products monitoring and post fire cleanup through development of Saffire-4, 5 and 6 fire safety flight experiments.
- Continue development of radiation sensors for flight on EM-1 and EM-2.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2018 – FY 2020

- Complete Bigelow Expandable Activity Module (BEAM) experiment on ISS to demonstrate inflatable structures technology for future habitats.
- Complete Phase 2 Next Space Technologies for Exploration Partnerships (NextSTEP) Broad Area Announcements to develop of prototype cislunar habitats for ground testing of subsystems, interfaces, and human factors.
- Deliver Brine Processor for launch to ISS to increase the amount of water recycled from urine.
- Deliver Spacecraft Atmosphere Monitor for launch to ISS to detect trace contaminants.
- Deliver five CubeSats for launch on SLS to search for lunar resources, fly by a near-Earth asteroid, and investigate the effects of deep space radiation on simple organisms.
- Deliver Universal Waste Management System (toilet) for launch to ISS.
- Complete ground testing (100 kW for 100 hours) of three advanced electric thrusters.
- Complete Radio Frequency Identification payload for Astrobee free flyer to track inventory on ISS.
- Complete Preliminary Design Review for Resource Prospector mission that will search for ice on the Moon.
- Determine deep space habitat acquisition approach.
- Complete Ascent Abort-2 flight test.
- Launch MOXIE on Mars 2020 mission.
- Complete Resource Prospector Critical Design Review.

PARTNER OVERVIEW

- **NASA Center(s):** All NASA Centers
- **Federal Agencies:** Department of Defense
- **International:** Korea, Taiwan
- **Academia:** Morehead State University
- **Industry:** Ad Astra, Aerojet Rocketdyne, Astrobotic, Bigelow Aerospace, The Boeing Company, Dynetics, Lockheed Martin, Masten Space Systems, Moon Express, MSNW, NanoRacks, Orbital ATK, Orbitec, Sierra Nevada Corp., United Technologies Aerospace Systems

PROGRAMS

HUMAN RESEARCH PROGRAM

PROGRAM WEBSITE - *https://www.nasa.gov/hrp*

SHORT DESCRIPTION

Sending astronauts into space involves a multitude of complicated systems, but perhaps the most complex is the human system. While NASA has amassed more than 50 years of crew experience in low Earth orbit, researchers continue to unravel the mysteries of how the human body responds to the harsh environment of space. HRP is responsible for understanding and mitigating the highest risks to astronaut health and performance to ensure that crews remain healthy and productive during long-duration missions beyond low Earth orbit.

As NASA prepares to conduct crewed missions in cislunar space using SLS and Orion, and eventually at other locations, including Mars, HRP is developing the scientific and technological expertise to send humans into deep space for longer durations. Coordinating with the National Academies, National Council on Radiation Protection, and other external partners, HRP continues to deliver products and strategies to protect crew health and safety, and maximize productivity while living and working in space. Experiments on the ISS, as well as in ground-based analog environments and laboratories, expand research and technology development for protecting the human system in multiple ways. Investigations regarding space radiation protection and health effects (cancer, central nervous and cardiovascular systems), deep space habitat systems, psychological support systems, innovative medical technologies, and new exploration capabilities, such as food systems, vehicle and space suit requirements, and validated countermeasure systems that ensure crew health during all phases of flight, are continuing to evolve. This knowledge is critical to NASA's plans for long-duration human space missions beyond low Earth orbit.

IMAGE 13.17

PROGRAMS

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017

- Initial data results are anticipated from One Year Mission—a joint U.S./Russian mission on ISS and Twins Study—looking at the effects of space flight on Scott Kelly during his one-year mission in contrast with his identical twin Mark Kelly who remained on Earth.
- Begin transition period for new Translational Research Institute (TRI) cooperative agreement - designed to lead the National effort in translating cutting-edge emerging terrestrial research into applied space flight human risk mitigation strategies for exploration missions.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2018 – FY 2020

- Implement second joint U.S. astronaut/Russian cosmonaut One-Year Mission to ISS in late 2018 and third One-Year Mission in 2019.
- Release new ISS flight research and ground-based analog NRA awards.
- Complete critical design review for Orion/exploration exercise system in preparation for EM-2 demonstration mission and replace the current Advanced Resistive Exercise Device on ISS.
- Integrate human HRP performance studies with National Science Foundation winter-over missions in Antarctica.
- Undertake joint long-term isolation/confinement studies with Russia and continue joint Envihab studies on human physiology (e.g., CO2 effects, Vision Impairment and Intracranial Pressure) with Germany and the ESA.
- Implement NASA Space Radiation Laboratory mixed-field capability to improve fidelity of space radiation research.

PARTNER OVERVIEW

- **NASA Center(s):** ARC, GRC, JSC, LaRC
- **Federal Agencies:** Department of Defense, Department of Energy, National Institutes of Health, National Science Foundation
- **International:** All International Partners
- **Academia:** Baylor College of Medicine cooperative agreement, research grants with over 250 leading National Universities
- **Industry:** Small Business Innovation Research (SBIR) to infuse technological solutions and capabilities

IMAGE 13.18

PROGRAMS

LAUNCH SERVICES PROGRAM

PROGRAM WEBSITE - *http://www.nasa.gov/centers/kennedy/launchingrockets/index.html*

SHORT DESCRIPTION

NASA's Launch Services Program (LSP) launches NASA's high-value satellites and interplanetary robotic missions, and provides the Agency affordable and reliable space access for uncrewed science exploration, communication, weather forecasting, and technology development customers. On the customer's behalf, LSP acts as the technical expert and matches NASA and other civil sector government spacecraft with commercially available launch services. This is done utilizing a competitive process created through the NASA Launch Services contract which is designed for procuring launch services from domestic commercial launch service suppliers. Once the right launch vehicle is selected, the program purchases a "ride to space" for the customer. Starting with pre-mission planning and continuing through the spacecraft's post-launch phase, LSP works with the customer and launch vehicle provider to maximize mission success. Essentially, LSP provides an instrumental capability that provides a dependable and reliable Earth-to-space bridge, for spacecraft to orbit the planet, or fly much further into our solar system and beyond.

In FY 2017 and beyond, LSP will continue working towards certifying new commercial launch vehicles (e.g., ULA Delta V Heavy, SpaceX Falcon 9 "Full Thrust" and Falcon Heavy, Orbital ATK Antares 230 series, etc.) to launch NASA's high-value payloads. Primary launch sites for NASA LSP managed launches are Cape Canaveral Air Force Station, Florida and Vandenberg Air Force Base, California. NASA's Wallops Island, Virginia, the Army's Reagan Test Site at Kwajalein Atoll in the Republic of the Marshall Islands in the North Pacific, and Kodiak Island, Alaska, are additional launch locations that have been used by LSP and its commercial launch service providers.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017

- Provide mission design and launch integration support to over 40 missions in various stages of development.
- In FY 2017 LSP plans to launch five missions such as the Geostationary Operational Environmental Satellite (GOES) R, the first in a series of three satellites that will provide continuous imagery and atmospheric measurements of Earth's Western Hemisphere and space weather monitoring and the Tracking and Data Relay Satellite (TDRS) M, part of a suite of space-based communication system satellites used to provide Tracking, Telemetry, Command, and high bandwidth data return services to its many customers.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2018 – FY 2020

- In FY 2018 LSP plans to launch five missions such as the Ice, Cloud, and land Elevation Satellite (ICESat)-2 a follow-on mission as a result of the 2007 Earth Science Decadal Survey; Interior Exploration using Seismic Investigations, Geodesy and Heat Transfer (InSight) to conduct a "check-up" of Mars, measuring its "pulse" or internal activity, temperature, and "reflexes"; and Solar Probe Plus a NASA mission to touch the Sun, which will be a historic mission flying into the Sun's atmosphere (or corona) for the first time.

PARTNER OVERVIEW

- **NASA Center(s):** KSC
- **Federal Agencies:** United States Air Force, Navy, FAA
- **International:**.N/A
- **Academia:** N/A
- **Industry:** Launch service providers: United Launch Services, Orbital ATK, SpaceX, Lockheed Martin Space Systems

LAUNCH SERVICES PROGRAM SETS STAGE FOR MISSION SUCCESS - *https://www.youtube.com/watch?v=b8EtGkpKOBA*

PROGRAMS

SPACE COMMUNICATIONS AND NAVIGATION

PROGRAM WEBSITE *- http://www.nasa.gov/scan*

SHORT DESCRIPTION

Space Communications and Navigation (SCaN) Program manages and operates NASA's space communications and tracking capabilities required for successful crewed (http://www.nasa.gov/topics/journeytomars/index.html) and robotic (http://www.nasa.gov/topics/solarsystem/index.html) spaceflight launches and missions, as well as for other government agencies. SCaN provides a critical lifeline to astronauts and spacecraft, uploading commands and essential crew instructions, and retrieving health, safety, and science data from spacecraft, and sending it to individual mission control centers. SCaN's three networks – the Deep Space Network (https://eyes.nasa.gov/dsn/dsn.html), Space Network, and Near Earth Network – provide these critical services to customer missions. SCaN also provides systems engineering, architecture planning, and developing advanced space communications and navigation technology concepts to efficiently integrate and plan current and future network capabilities to meet customer mission needs while reducing costs. As a cross-cutting Agency function, SCaN also implements NASA's requirements in several national and international arenas, including the management of NASA's Radio Frequency Spectrum on behalf of the Administrator, advocacy and coordination of Agency requirements for the positioning, navigation and timing services provided by the Global Positioning System, and space communication standards.

SCaN's customers include the Hubble Space Telescope in Earth orbit, the Curiosity rover on the surface of Mars, and the New Horizons robotic mission reporting science data after its successful flyby of the dwarf planet Pluto, and its moon, Charon. The Program supports the ISS as well as its commercial and international servicing vehicles, and will support commercial crew providers and the future launches of the SLS and Orion crew vehicle. SCaN will also provide the vital communications links with the James Webb Space Telescope after launch in late 2018. Additionally, SCaN provides services to foreign governments, international partners, and non-NASA U.S. missions on a reimbursable basis.

IMAGE 13.19

PROGRAMS

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017

- Launch Tracking and Data Relay Satellite (TDRS) M spacecraft in August 2017 and insert into orbit as part of TDRS System.
- Maintain extremely high levels of operational proficiency for all three networks.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2018 – FY 2020

- Continue work towards completion of Space Network Ground Segment Sustainment Project to implement a flexible and extensible ground segment that will allow the Space Network to maintain high levels of service in the future, accommodate new users and capabilities, while reducing the effort required to operate and maintain the system.
- Enhance the capabilities of the Deep Space Network (DSN) through the DSN Aperture Enhance Project by completing Deep Space Station (DSS) 56 by October 2019 and DSS-53 by October 2020.
- Complete assessment of industry concepts for the generation data relay satellite capabilities and award follow-on study contracts.
- Insert new technologies into next generation Near Earth and Deep Space Network systems, including support system acquisition, maturing optical communications (near-Earth and deep space), space internetworking, cognitive radios, and other technologies needed to enable future missions.
- Cooperate with the National Telecommunications and Information Administration Policy and Plans Steering Group in identifying Federal spectrum for auction and repurpose for commercial mobile broadband. This effort, sponsored by Presidential Initiative, intends to identify 500 MHz of spectrum for mobile broadband use within 10 years, while ensuring critical Federal operations are not adversely impacted.

PARTNER OVERVIEW

- **NASA Center(s):** GSFC, GRC, JPL-FFRDC
- **Federal Agencies:** Department of State, Department of Commerce/National Telecommunications and Information Administration, US Air Force and other U.S. Government Agencies
- **International:** Bilateral cooperation on space communication capabilities with a variety of NASA's international partners; bilateral agreements with Spanish and Australian Space agencies related to NASA's Deep Space Network complexes located in those countries; and international participation in organizations such as Interagency Operations Advisory Group, Consultative Committee for Space Data Systems, Space Frequency Coordination Group, and the United Nations' International Telecommunications Union (193 participating nations) and International Committee on Global Navigation Satellite System)
- **Academia:** MIT/Lincoln Laboratory
- **Industry:** Boeing Space Systems, Harris Corporation, and General Dynamics

PROGRAMS

HUMAN SPACE FLIGHT OPERATIONS

SHORT DESCRIPTION

Human Space Flight Operations (HSFO) program supports the training, readiness, and health of crewmembers before, during, and after each space flight mission to the ISS. All crews on board the Space Station have undergone rigorous preparation, which is critical to mission success. Within the HSFO program, the Space Flight Crew Operations (SFCO) element provides the capability for astronaut selection and training while the Crew Health and Safety (CHS) element manages all aspects of astronaut crew health.

SFCO provides trained astronauts for all NASA human space flight mission which begins with selecting astronaut candidates, and includes managing flight crew activities, recommending mission assignments, and operating support and training aircraft. Using a curriculum validated by the National Academy in their report, Preparing for the High Frontier, (NRC, 2011), astronaut training takes 12-18 months from selecting a new astronaut class until their successful acceptance to be assigned to a mission and then another 30 months of ISS training before a new astronaut reaches the ISS. Astronaut training is consistent with ISS and exploration manifest requirements and includes supporting Soyuz, as well as projected Commercial Crew and Orion/SLS development flights.

CHS is responsible for the medical screening of astronaut candidates as part of the selection process and maintaining their health during all phases of space flight missions. In addition, CHS works to prevent and mitigate negative long-term health consequences from exposure to the space flight environment. CHS collaborates with the Human Research Program (HRP) to transition research results into operational health protocols. As research continues on ISS through 2024, CHS will collaborate with other Federal agencies to seek new ways of protecting the astronauts. CHS focuses on preventive care, managing health risks, and long-term health monitoring. CHS documents and assesses all emerging health risks, such as potential impacts on the visual system and collaborates with a number of non-NASA organizations, such as the National Academies, seeking solutions to reduce the risk.

IMAGE 13.20

PROGRAMS

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017

- Support future ISS Expedition flight crew training requirements and ISS mission operations with typically eight astronauts in training curriculum per year.
- Support flight crew training requirements and mission operations for test flights of the NASA crewed SpaceX Dragon and Boeing Starliner commercial spacecraft.
- Operate support aircraft to provide a more reliable transportation system for direct crew return from Kazakhstan (Soyuz) and from commercial spacecraft landing, conduct flight readiness training, and provide "Super Guppy" transport for oversized cargo such as Orion's heat shield.
- Meet crew member pre-flight training, medical, behavioral health management, physical conditioning and baseline occupational surveillance requirements in support of ISS for future increments at a rate of four per year.
- Support in-flight medical and behavioral health management operations, implement and monitor onboard physical conditioning and in-flight occupational surveillance requirements during ISS increments involving 8 crewmembers per year.
- Provide post-flight clinical, behavioral and reconditioning services to NASA crew members returning to Earth.
- Evaluate the Orion/SLS EM-1 mission for radiation environmental data to support future crewed flights.
- Provide preflight and operations support to test flights of NASA crewed SpaceX Dragon and Boeing CST-100 Starliner commercial spacecraft.
- Provide medical and behavioral certification services for the supporting the selection of the Astronaut Class of 2017 and potential Class of 2020.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2018 – FY 2020

- Begin training the FY 2017 Astronaut Candidate class (18-month training cycle).
- Support selection process for potential FY 2020 Astronaut Candidate class.

PARTNER OVERVIEW

- **NASA Center(s):** JSC
- **Federal Agencies:** N/A
- **International:** N/A
- **Academia:** N/A
- **Industry:** DynCorp International LLC, Wyle Integrated Science and Engineering Group

IMAGE 13.21

ROCKET PROPULSION TEST

PROGRAM WEBSITE - *http://rockettest.nasa.gov*

SHORT DESCRIPTION

NASA's Rocket Propulsion Test (RPT) program maintains and manages a wide range of facilities for ground testing rocket engines and components under controlled conditions. This world-class test organization includes facilities located across the United States and a highly-skilled workforce, capable of performing tests on all modern day rocket engines. RPT provides a single entry point for any user of the rocket test stands, including the Department of Defense, other Government Agencies, and aerospace contractors. RPT is critical for NASA's journey to Mars, providing affordable and reliable rocket test capabilities (such as the B-2 stand at the Stennis Space Center for testing of the SLS Core Stage and Exploration Upper Stage (EUS) to ensure the safety of exploration systems.

The program has instituted policies and procedures to transition facilities to different readiness states to effectively meet customer requirements and reduce operations and maintenance budgets. This allows the program to manage facility usage and eliminate redundant capabilities by closing, consolidating, and streamlining test facilities. In addition, the program approves and provides direction on test assignments, capital improvements, and facility modernization and refurbishment. RPT integrates multi-site test activities, identifies and protects core capabilities, and develops advanced testing technologies.

RPT is the NASA representative for the National Rocket Propulsion Test Alliance (NRPTA)—an interagency collaboration with the Department of Defense to facilitate efficient and effective use of the Federal Government's rocket propulsion test capabilities. The RPT Program Manager serves as a co-chair of the NRPTA Senior Steering Group.

IMAGE 13.22

PROGRAMS

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017

- Complete refurbishment of B-2 test stand for SLS Core Stage testing in support of Exploration Mission-1 (EM-1), an uncrewed test flight of SLS and Orion around the Moon.
- Prepare for testing of the EUS at the SSC B-2 test stand, which will begin in October 2020.
- Perform technology development testing of "additive manufacturing" engine components, which could be used to lower manufacturing costs.
- Perform acceptance and qualification testing of European Space Agency provided Service Module for the Orion crew vehicle.
- Perform acceptance and qualification testing of the Boeing CCT-100 Service Module, as well as its reaction control system thrusters, orbital maneuvering and control thrusters, and launch abort engines.
- Test in support of U.S. National defense systems including the USAF Minuteman missile, U.S. Navy missiles, and other testing for the Missile Defense Agency.
- Prepare to demolish test stands at WSTF and MSFC, which consolidates facilities, reducing costs.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2018 – FY 2020

- Perform hot-fire testing of SLS Core Stage in support of EM-1.
- Complete facility modifications required to test RS-25 engines--a key component of the SLS Core Stage.
- Complete refurbishing the A-2 test stand at SSC in preparation of reimbursable Aerojet Rocketdyne AR-1 engine testing (a part of the National effort to eliminate reliance on the Russian RD-180 engine).
- Perform Aerojet Rocketdyne RS-68 engine testing in support USAF launch activities, AR-1 component development, and SpaceX combustion device testing.
- Perform eCryo SHIVER (Structural Heat Intercept, Insulation and Vibration Evaluation Rig) testing on cryogenic fluid management technologies in a simulated space environment in support of SLS.
- Invest in test facility consolidation and modernization across the Agency.

PARTNER OVERVIEW

- **NASA Center(s):** GRC—Plum Brook Station, JSC —White Sands Test Facility, MSFC, SSC
- **Federal Agencies:** Department of Defense
- **International:** N/A
- **Academia:** N/A
- **Industry:** N/A

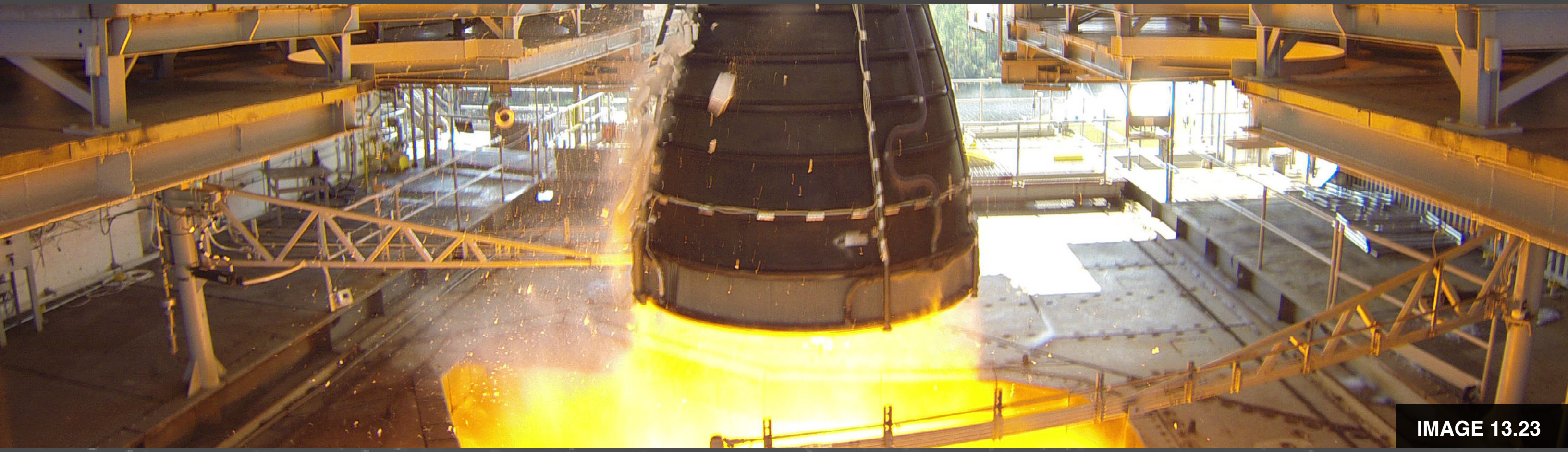


IMAGE 13.23

APPROACH TO MISSIONS

The NASA Science Mission Directorate (SMD) leads the Nation on a great journey of discovery. SMD accomplishes this through four science divisions – Heliophysics, Earth Science, Planetary Science, and Astrophysics – that seek answers to: *How is the Earth system changing? What causes the Sun to vary? How did the solar system form and evolve? How did the Universe begin? Are we alone?* All the divisions are interconnected as SMD is an organization where discoveries in one scientific discipline have a direct route to other areas of study.

The National Aeronautics and Space Act of 1958 established NASA's mandate to conduct activities in space to accomplish national objectives, including "the expansion of human knowledge of the Earth and of phenomena in the atmosphere and space" and "the development and operation of vehicles capable of carrying instruments, equipment, supplies, and living organisms through space." NASA follows this, the Authorization Acts of 2005, 2008, 2010, and the National Space Policy of 2010, to carry out its science program. Additionally, the Nation's greatest scientific minds via the National Academy of Sciences (NAS), Engineering and Medicine prioritize and recommend approaches to answer profound questions through decadal recommendations to SMD and other research agencies. Using these decadal surveys and armed with the directives of the U.S. Government, SMD develops science objectives and programs to lay the intellectual foundation for the robotic and human expeditions of the future, and lead the Nation in economic, scientific and technological growth. Operating or building over 100 missions, the Nation's investment is maximized through SMD.

Building upon the Nation's investment, SMD will execute over ten launches in 2017, and the first total solar eclipse across the entire country in almost a century occurs August 21, 2017. The launch of the Solar Probe Plus mission in July 2018 will fulfill one of the highest heliophysics priorities over the past 5 decades, sending this spacecraft closest to the Sun than ever before. But the showpiece will occur October 2018 with the launch of the premier observatory, the James Webb Space Telescope (JWST). The JWST will peer into the early universe and the formation of galaxies and stars, as well as planetary systems and their potential for life. All of these missions and partnerships advance the science, technology, engineering and mathematics (STEM) workforce pipeline and drive technological innovation, and help ensure we have the knowledge and tools to protect our homeland.

IMAGE 13.24

APPROACH TO MISSIONS

HIGHLIGHTS OF KEY ACHIEVEMENTS FOR 2016

- Launched the Origins, Spectral Interpretation, Resource Identification, and Security-Regolith Explorer (OSIRIS-REx) on its 2-year journey to the near-Earth asteroid Bennu.
- Initiated the formulation phase for Earth Science Plankton, Aerosols, Clouds, and Ocean Ecosystem (PACE) and Landsat-9 missions.
- Delivered flight hardware and completed integration of the Gravity Recovery and Climate Experiment Follow-on GRACE-FO) observatory.
- The Ice, Cloud, and land Elevation Satellite-2 (ICESat-2) is undergoing assembly and testing.
- Successfully inserted the Juno spacecraft in Jupiter orbit on July 4, 2016; science is underway.
- Entered formulation phase for Europa flyby mission.
- Confirmed Mars 2020 mission to begin implementation.
- Established the Planetary Defense Coordination Office (PDCO) to monitor Near Earth Objects (NEO).
- Established Interagency Working Group (IWG) for Deflecting and Mitigating the Impact of Earth-bound Near-Earth Objects (DAMIEN) to develop the National Strategy and Action plan for U.S. government preparedness for a NEO impact hazard.
- Awarded five concept studies for one or two future Discovery missions to launch in approximately 2021.
- Completed two studies for the Mars human landing site selection effort, to understand the potential of water feedstocks and what it will take to produce usable water from them.
- The Wide Field Infrared Survey Telescope (WFIRST) entered its formulation phase.
- Kepler's discovery of exoplanet candidates exceeded 4,000, including 10 Earth-size planets orbiting in the habitable zone of their host stars and which could have their atmospheres measured by the James Web Space Telescope (JWST).
- The Stratospheric Observatory for Infrared Astronomy (SOFIA) produced high-impact science results that attracted strong public interest: atmospheric atomic oxygen on Mars, water around a star in-the-making, catching an incredibly rapid transition of an aging star expelling carbon, and clues to the formation of organic molecules that could be the building blocks of life.
- Completed installation of JWST mirror segments and integrated Optical Telescope Element (OTE) and Integrated Science Instrument Module (ISIM) to form the Optical Telescope Element and Integrated Science (OTIS) Instrument Model.
- Chandra and optical observations found the smallest supermassive black hole (mass 50,000 times that of the Sun) in the dwarf galaxy RGG118.
- Solar Probe Plus (SPP) completed hardware development and entered integration and testing phase to support a 2018 launch.
- Released Announcement of Opportunity for future Heliophysics Small Explorer (SMEX) missions.
- Launched of Jason-3 spacecraft for National Oceanic and Atmospheric Administration (NOAA) to measure ocean surface height.
- Transitioned the Deep Space Climate Observer (DSCOVR) spacecraft to become the principal space weather operational asset for NOAA's Space Weather Prediction Center (SWPC).

ICE, CLOUD, AND LAND ELEVATION SATELLITE 2 (ICESAT-2)

PROGRAM WEBSITE - *http://icesat.gsfc.nasa.gov/index.php*

IMAGE 13.25

SHORT DESCRIPTION

The ICESat-2 mission will serve as an ICESat follow-on satellite to continue the assessment of polar ice changes. ICESat-2 will also measure vegetation canopy heights, allowing estimates of biomass and carbon in above-ground vegetation in conjunction with related missions, and allow measurements of solid earth properties. ICESat-2 will continue to provide an important record of multi-year elevation data needed to determine ice sheet mass balance and cloud property information. It will also provide topography and vegetation data around the globe in addition to the polar-specific coverage over the Greenland and Antarctic ice sheets. The ICESat-2 mission is a Tier 1 mission, recommended by the National Academies. It entered formulation in FY 2010 and entered implementation in FY 2013. The ICESat-2 observatory employs a dedicated spacecraft with a multi-beam photon-counting surface elevation lidar, which measures distance by illuminating the Earth's surface with a laser and analyzing the reflected light. ICESat-2 will continue the measurements begun with the first ICESat mission, which launched in 2003, and will improve upon ICESat by incorporating a micro-pulse multi-beam laser to provide dense cross-track sampling, improving elevation estimates over inclined surfaces and very rough (e.g., crevassed) areas and improving lead detection for above-water sea ice estimates.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Complete integration of spacecraft in FY 2017.
- Launch in FY 2018.

PARTNER OVERVIEW

- **NASA Center(s):** Goddard Space Flight Center(GSFC)
- **Federal Agencies:** N/A
- **International:** N/A
- **Academia:** N/A
- **Industry:** N/A

GRAVITY RECOVERY AND CLIMATE EXPERIMENT-FOLLOW ON (GRACE-FO)

PROGRAM WEBSITE *- http://gracefo.jpl.nasa.gov*

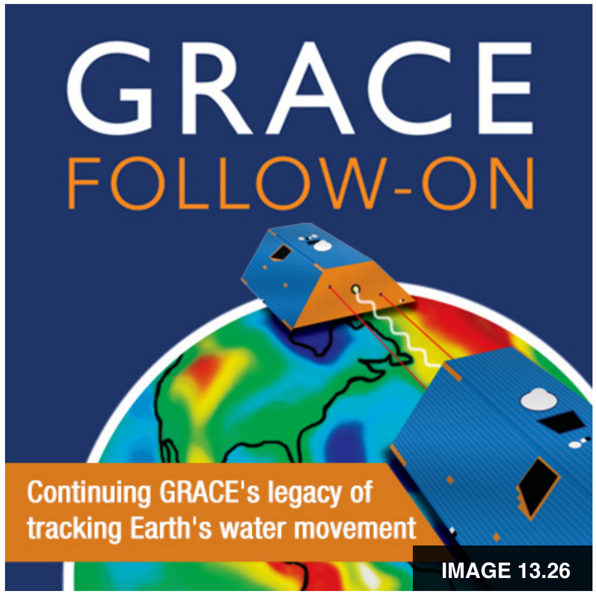


IMAGE 13.26

SHORT DESCRIPTION

The GRACE-FO mission will allow scientists to gain new insights into the dynamic processes in Earth's interior, currents in the oceans, and variations in the extent of ice coverage. Data from the mission, combined with other existing sources of data, will greatly improve scientific understanding of glaciers and hydrology. GRACE-FO will obtain the same extremely high-resolution global models of Earth's gravity field, including how it varies over time, as in the original GRACE mission (launched in 2002). GRACE-FO data is vital to ensuring there is a minimal gap in gravitational field measurements following the decommissioning of the currently operating GRACE mission. GRACE-FO includes a partnership with the German Research Centre for Geosciences (GFZ). The GRACE-FO observatory employs two dedicated spacecraft, launched into a near-circular polar orbit. As the two spacecraft orbit Earth, slight variations in gravity will alter the spacecraft speed and distance relative to each other. Scientists use the speed and distance changes to extrapolate and map Earth's gravitational field. The GRACE-FO instrument suite includes the Microwave Instrument, which accurately measures changes in the speed and distance between the two spacecraft. The accelerometer instrument measures all non-gravitational accelerations (e.g., atmospheric drag, solar radiation pressure, attitude control, and thruster operation) on each GRACE-FO satellite. The Laser Ranging Interferometer is a technology demonstration and is a partnership between the United States and Germany. The launch vehicle will be provided by GFZ. NASA will use the science data from the GRACE-FO mission to generate an updated model of Earth's gravitational field approximately every 30 days for the 5-year lifetime of the prime mission.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Launch of GRACE-FO is planned for FY 2018.

PARTNER OVERVIEW

- **NASA Center(s):** Jet Propulsion Laboratory – Federally Funded Research and Development Center (JPL-FFRDC)
- **Federal Agencies:** N/A
- **International:** German Research Centre for Geosciences (GFZ)
- **Academia:** N/A
- **Industry:** N/A

SURFACE WATER AND OCEAN TOPOGRAPHY (SWOT)

PROGRAM WEBSITE - *http://swot.jpl.nasa.gov*

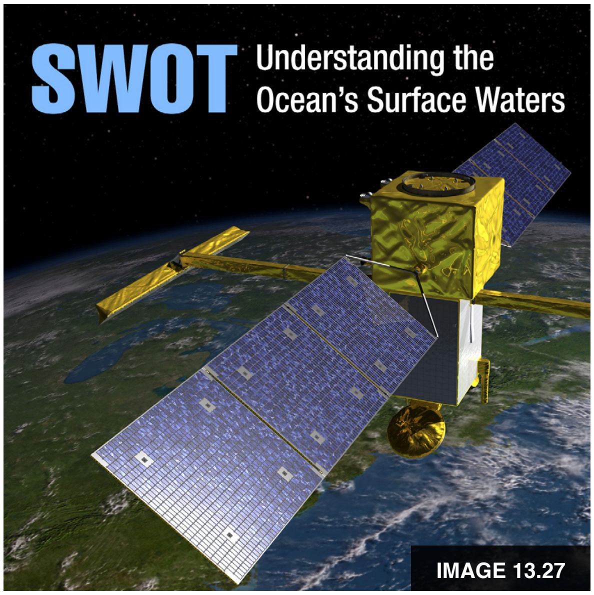


IMAGE 13.27

SHORT DESCRIPTION

The SWOT mission will improve our understanding of the world's oceans and terrestrial surface waters. The mission, through broad swath altimetry, will make high-resolution measurements of ocean circulation, its kinetic energy, and its dissipation. These measurements will improve ocean circulation models, leading to better prediction of weather and climate. The mission will also revolutionize knowledge of the surface water inventory on the continents by precise measurement of water levels in millions of lakes and water bodies and the discharge of all major rivers. This will allow for deeper understanding of the natural water cycle and the informed control of this resource. The 2007 National Academies decadal survey of Earth Science and the NASA's 2010 Climate Plan endorsed SWOT. The mission will complement the Jason oceanography missions, as well as other NASA missions currently in operation and development to measure the global water cycle (Global Precipitation Measurement (GPM), Soil Moisture Active Passive (SMAP), and GRACE-FO). NASA will collaborate with the French Space Agency, Canadian Space Agency, and United Kingdom Space Agency to accomplish this mission. SWOT will provide broad-swath sea surface heights and terrestrial water heights for at least 90 percent of the globe using a dual-antenna Ka-band Radar Interferometer (KaRIn). The SWOT payload will also include a precision orbit determination system consisting of Global Positioning System-Payload (GPSP), Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) receivers, and a Laser Retro-reflector Assembly (LRA). In addition, SWOT carries a Nadir Altimeter, and a radiometer for tropospheric path delay corrections. SWOT is planned for launch in FY 2022. The mission will operate for three years.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Complete mission Critical Design Review in FY 2017.

PARTNER OVERVIEW

- **NASA Center(s):** JPL-FFRDC
- **Federal Agencies:** N/A
- **International:** French Space Agency (CNES), Canadian Space Agency (CSA), United Kingdom Space Agency (UKSA)
- **Academia:** N/A
- **Industry:** N/A

NASA-ISRO SYNTHETIC APERTURE RADAR (NISAR)

PROGRAM WEBSITE *- http://nisar.jpl.nasa.gov/*

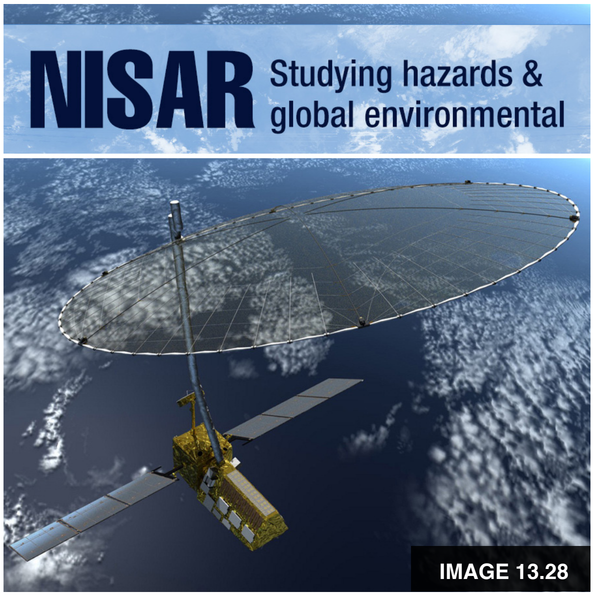


IMAGE 13.28

SHORT DESCRIPTION

The NISAR mission will provide an unprecedented, detailed view of the Earth using advanced radar imaging. The NISAR satellite will observe and take measurements of some of the planet's most complex processes, including ecosystem disturbances, ice sheet collapses, and natural hazards, such as earthquakes, tsunamis, volcanoes, and landslides. NISAR is a dual frequency (L- and S-band) Synthetic Aperture Radar (SAR) mission, and data collected by the NISAR satellite will reveal information about the evolution and state of Earth's crust, help scientists better understand our planet's processes and changing climate, and aid future resource and hazard management. The mission is currently in formulation in partnership with ISRO. Scientists have proposed L-band SAR missions in various forms for over a decade. Scientists derived the L-band SAR science of the NISAR mission from Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI),a 2007 Decadal Survey Tier 1 mission recommended by the National Academies. NASA will provide the L-band SAR. ISRO will provide the S-band SAR, the spacecraft bus, the launch vehicle, observatory integration and testing, and spacecraft operations. NASA and JPL-FFRDC will be providing the L-band SAR instrument and associated payload elements, including L-band electronics, radar feed, reflector and boom assembly, solid state recorder, GPS receiver, high-rate telecom system, and payload data subsystem. NISAR is planned for launch in FY 2022.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Complete the design of the NISAR mission in FY 2017.
- Complete Critical Design Review in FY 2018.

PARTNER OVERVIEW

- **NASA Center(s):** JPL - FFRDC
- **Federal Agencies:** N/A
- **International:** Indian Space Research Organisation (ISRO)
- **Academia:** N/A
- **Industry:** N/A

LANDSAT 9

PROGRAM WEBSITE *- http://landsat.gsfc.nasa.gov/*

IMAGE 13.29

SHORT DESCRIPTION

The Landsat 9 mission is the successor mission to Landsat Data Continuity Mission (LDCM) – renamed Landsat 8 after commissioning in May 2013. Landsat satellites have continuously acquired multispectral images of the global land surface since the launch of Landsat 1 in 1972. The Landsat data archive constitutes the longest continuous moderate-resolution record of the global land surface as viewed from space. The Landsat 9 mission objective is to extend the ability to detect and quantitatively characterize changes on the global land surface at a scale where natural and human-induced causes of change can be detected and differentiated. Landsat data supports a broad range of users with monitoring and change/trend detection needs including land cover/land use change, crop and vegetation health, and – especially in the western U.S. – essential high-resolution, regional-extent monitoring of evapotranspiration and water use, made possible by high-quality measurements in the thermal infrared band. The FY 2016 President's Budget Request, called for a Sustainable Land Imaging (SLI) program to enable the development of a multi-decade, spaceborne system that will (a) provide U.S. users with high-quality global land-imaging measurements that are compatible with the existing 43-year plus record, (b) address near- and longer-term issues of continuity risk, and (c) evolve flexibly and responsibly through investment in, and introduction of, new sensor and system technologies. Landsat 9 is one of the first elements of the SLI architecture, and a single spacecraft mission that will fly near-identical copies of the Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) instruments that were flown on Landsat-8. The TIRS instrument will be upgraded to a risk class B implementation, whereas no changes are planned for OLI. With respect to the Landsat 9 project, these instruments will be referred to as OLI-2 and TIRS-2. The OLI-2 instrument provides Visible and Near Infrared / Short Wave Infrared (VNIR/SWIR) imagery consistent with previous Landsat spectral, spatial, radiometric and geometric qualities. The TIRS-2 instrument is a two-band thermal imaging sensor providing imagery sufficiently consistent with Landsat 8 thermal spectral, spatial, radiometric and geometric qualities to enable consistent retrieval of surface temperature. Landsat 8 designs and subsystems will be used to the extent possible to minimize cost, schedule, and risk. The allocation of responsibilities between NASA and USGS will be a very similar agency split as was implemented for Landsat 8. The responsibilities for Landsat 9 project implementation are largely divided between mission segment areas; NASA is responsible for the development of the Space Segment and Launch Segment and the United States Geological Survey (USGS) is responsible for the development of the Ground Segment. USGS is also responsible for Landsat 9 mission operations after completion of the on-orbit checkout period, including image-data collection, management, and distribution. NASA will serve as the system integrator for the entire Landsat 9 project and lead the mission systems engineering and mission assurance efforts through the on-orbit checkout period. After on-orbit checkout, primary responsibility for the Landsat 9 mission and its operation transfers from NASA to USGS. Landsat 9 is targeting a launch in FY 2021.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Award spacecraft contract, initiation of the launch vehicle procurement, and sign interagency agreement between NASA and USGS in FY 2017.
- Deliver all mission flight hardware in FY 2020.

PARTNER OVERVIEW

- **NASA Center(s):** GSFC
- **Federal Agencies:** United States Geological Survey (USGS)
- **International:** N/A
- **Academia:** N/A
- **Industry:** N/A

PLANKTON, AEROSOLS, CLOUDS, AND OCEAN ECOSYSTEM (PACE)

PROGRAM WEBSITE - *http://pace.gsfc.nasa.gov/*

IMAGE 13.30

SHORT DESCRIPTION

PACE is a strategic Climate Continuity mission, defined in the 2010 plan, Responding to the Challenge of Climate and Environmental Change: NASA's Plan for Climate-Centric Architecture for Earth Observations and Applications from Space. PACE will be a polar-orbiting mission with an ocean color sensor and an aerosol-cloud polarimeter. The mission will be capable of performing radiometric and polarimetric ocean and atmosphere data collection, returning a range of geophysical data from which properties of the ocean and atmosphere can be determined, to add to other critical climate and Earth system records. PACE will extend key, systematic, global ocean biological, ecological, and biogeochemical climate data records, as well as aerosol climate data. The climate-quality global ocean color measurements are essential for understanding the global carbon cycle and global ocean ecology. It will also determine how the oceans' role in global biogeochemical cycling and ocean biology and ecology both affects, and is affected by, climate change. PACE will also make key observations of aerosols and clouds, focusing on reducing the largest uncertainty in physical climate and in radiative forcing of the global Earth system. This will provide better quantitative estimates of aerosol type and height, improving our understanding of atmospheric dynamics and radiative sciences. It will also improve the atmospheric correction for ocean color remote sensing. PACE is targeting a launch in FY 2022.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Complete Systems Requirement Review/Mission Definition Review, and Key Decision Point B in FY 2017.

PARTNER OVERVIEW

- **NASA Center(s):** GSFC
- **Federal Agencies:** N/A
- **International:** N/A
- **Academia:** N/A
- **Industry:** N/A

EARTH SCIENCE PROGRAMS

SENTINEL 6A/B

PROGRAM WEBSITE *- http://eospso.nasa.gov/missions/sentinel-6a*

SHORT DESCRIPTION

The Sentinel-6A/B mission is a U.S.-European cooperation involving NASA, the National Oceanic and Atmospheric Administration (NOAA), the European Space Agency (ESA), and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). It involves NASA-led U.S. participation in the development, launch, and on-orbit exploitation of two precision altimeter satellites for launch in FY 2021 and FY 2026, to measure sea-level as part of the European Copernicus system of Earth observing satellites. The 2016 President's Budget Request established a new framework in which NOAA is responsible for satellites that contribute directly to its weather and space weather missions, while NASA is responsible for other civil Earth-observing satellite missions. This resulted in the transfer of responsibility to NASA for ocean altimetry missions, including the Sentinel-6A and -6B satellites, beginning in 2016. Funds to implement the Administration proposal were appropriated by Congress in late December 2015. Accordingly, NASA inherited the Sentinel-6 acquisition strategy established prior to the transfer of responsibility from NOAA- as the previous lead agency for the U.S. - had developed in the context of the partnership with ESA and EUMETSAT. This implementation/acquisition/workshare strategy is codified in the Memorandum of Understanding (MOU) that is currently routing for approval with the partners. The acquisition scope and approach inherited by NASA entails two sets of instruments, one each for the Sentinel-6A and Sentinel-6B spacecraft, consisting of substantial rebuilds of the Advanced Microwave Radiometer – Climate Quality (AMR-C) from the OSTM/Jason-2, Jason-3, and the Surface Water and Ocean Topography (SWOT) missions; substantial rebuilds of the Global Navigation Satellite System for Radio Occultation (GNSS-RO) receiver from the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC)-2 mission with minor software updates, a 1553 interface, and radio occultation antennas adapted from the COSMIC-1 mission; and build-to-print copies of the Laser Retroreflector Array (LRA) from Jason-3. The NASA workshare/approach also includes provision of two intermediate class launch vehicles and services for the Sentinel-6A and Sentinel-6B spacecraft that will be competitively procured through standard NASA Launch Services Program (LSP) processes. JPL-FFRDC is the Implementing Center given its role on Sentinel-6 supporting NOAA on a reimbursable basis prior to the transfer of the project to NASA, and its expertise, involvement, and previous accomplishments for all previous NASA altimeter missions. Sentinel 6A is targeted for launch in FY 2021 and Sentinel 6B is targeted for launch in FY 2026.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Complete Key Decision Point C and establish Agency Baseline Commitment in FY 2017.

PARTNER OVERVIEW

- **NASA Center(s):** JPL-FFRDC
- **Federal Agencies:** NOAA
- **International:** European Space Agency (ESA), European Organisation for the Exploitation of Meteorological Satellites
- **Academia:** N/A
- **Industry:** N/A

EARTH VENTURE-CLASS PROJECTS

PROGRAM WEBSITE - http://eospso.nasa.gov/mission-category/13

SHORT DESCRIPTION

Earth Venture was introduced to NASA's Earth Science Program as part of a strategy to restore more frequent launch opportunities and to facilitate the demonstration of innovative ideas and higher-risk technologies. It is a scientifically broad-reaching program element that regularly solicits small-scale orbital and suborbital missions, and orbital instruments. Venture-class investigations complement the larger systematic missions identified in the Earth Science decadal survey, providing flexibility to accommodate scientific advances and new implementation approaches. Venture-Class comprises three "strands":

Earth Venture Suborbital (EVS)
Suborbital/airborne investigations, with five-year durations from project initiation. These are typically complex sets of instruments flown on suitable suborbital platforms to address focused sets of scientific questions. The first five EVS investigations were selected in FY 2010 and completed in FY 2016. The second six EVS investigations were selected in FY 2015. Solicitations will be issued every four years.

Earth Venture Mission (EVM)
Small complete missions; ~$150 million total cost. These can be small satellites or stand-alone payloads as part of a larger mission. The first EVM small mission, CYclone Global Navigation Satellite System (CYGNSS), was selected in 2012. CYGNSS is a constellation of microsatellites that will study ocean surface winds. The second EVM selection will be made in CY 2016. Solicitations will be issued every four years.

Earth Venture Instrument (EVI)
Spaceborne instruments for flight on a Mission of Opportunity (MoO); ~$90 million total cost for development and operations. The first EVI selection was made in FY 2013 for the Tropospheric Emissions: Monitoring of Pollution (TEMPO). TEMPO is a geostationary instrument that will measure atmospheric pollution covering most of North America hourly and at high spatial resolution. The second EVI selections were made in FY 2014 for two International Space Station payloads: Global Ecosystem Dynamics Investigation Lidar (GEDI) and ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS). GEDI will characterize the effects of changing climate and land use on ecosystem structure and dynamics to enable radically improved quantification and understanding of the Earth's carbon cycle and biodiversity. ECOSTRESS will address critical questions on plant–water dynamics and future ecosystem changes with climate through an optimal combination of thermal infrared (TIR) measurements over the diurnal cycle for a wide range of biomes with high spatiotemporal. The third EVI selection was made in FY 2016 for the Multi-Angle Imager for Aerosols (MAIA) and Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats (TROPICS). MAIA project will combine MAIA air pollution measurements with population health records to better understand the connections between aerosol pollutants and health problems such as adverse birth outcomes, cardiovascular and respiratory diseases and premature deaths. TROPICS is a cubesat constellation that will observe the thermodynamics and precipitation structure of tropical cyclones. EVI Solicitations will be issued every 15-18 months.

EARTH SCIENCE PROGRAMS

In selecting Venture Class missions, instruments and suborbital investigations, priority is given to cost-effective, innovative missions rather than those with more demanding scientific and technological requirements. Maintaining a steady stream of opportunities for community participation in the development of innovative ideas is key to the success of Earth Venture. The selected investigations will be strictly held to schedule and cost guidelines to ensure the long-term viability of the program.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Launch CYGNSS in FY2017.
- Deliver TEMPO instrument to a host spacecraft in FY2018.
- Deliver GEDI instrument to the ISS in FY2018.
- Deliver ECOSTRESS instrument to the ISS in FY2019.

PARTNER OVERVIEW

- **NASA Center(s):** Ames Research Center(ARC), Langley Research Center (LaRC), JPL - FFRDC
- **Federal Agencies:** NOAA
- **International:** Bermuda Institute of Ocean Sciences, European Space Agency (ESA), European Organisation for the Exploitation of Meteorological Satellites
- **Academia:** Harvard-Smithsonian Center for Astrophysics, Harvard University, Massachusetts Institute of Technology-Lincoln Laboratory, Oregon State University, Pennsylvania State University, University of Maryland, University of Michigan
- **Industry:** Southwest Research Institute

ORIGINS, SPECTRAL INTERPRETATION, RESOURCE IDENTIFICATION, AND SECURITY - REGOLITH EXPLORER (OSIRIS-REX)

PROGRAM WEBSITE - *http://science.nasa.gov/missions/osiris-rex*

IMAGE 13.31

SHORT DESCRIPTION

The Origins, Spectral Interpretation, Resource Identification, and Security-Regolith Explorer (OSIRIS-REx) spacecraft will travel to Bennu, a near-Earth carbonaceous asteroid formerly designated 1999 RQ36, to study the asteroid in detail and bring back a sample (at least 60 grams or 2.1 ounces) to Earth. This sample will yield insight into planet formation and the origin of life, and the data collected at the asteroid will aid in understanding asteroids that can collide with Earth. This mission will also measure the Yarkovsky effect on a potentially hazardous asteroid and measure the asteroid properties that contribute to this effect. By describing the integrated global properties of a primitive carbonaceous asteroid, this mission will allow for direct comparison with ground-based telescopic data of the entire asteroid population.

OSIRIS-REx has connections with both the Asteroid Redirect Mission (ARM) and the Planetary Defense Coordination Office (PDCO). The lessons OSIRIS-REx will learn at Bennu will write the handbook for future asteroid missions, beginning with ARM. For Planetary Defense, there are far more Near-Earth Objects (NEOs) than we can visit with spacecraft. Our ability to predict the path of a NEO and other key physical parameters will depend upon how good our models are, models of the Yarkovsky effect that influence the NEOs trajectory, as well as models of the structure of the NEO, where it came from, what it is made up of, and how solid it is. One of the science goals of OSIRIS-REx is to test and improve our models in these areas.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Perform fly-by of Earth for a gravitational assist and to obtain calibration observations of Earth and the Moon in FY 2017.
- Arrive at the asteroid Bennu and begin the process to map and characterize the surface in FY 2018.
- Acquire sample from Bennu in FY 2020.

PARTNER OVERVIEW

- **NASA Center(s):** GSFC, Marshall Space Flight Center (MSFC), Kennedy Space Center (KSC), Johnson Space Center (JSC)
- **Federal Agencies:** N/A
- **International:** Canadian Space Agency (CSA)
- **Academia:** Arizona State University, Massachusetts Institute of Technology, University of Arizona, Harvard University
- **Industry:** Lockheed Martin

PLANETARY SCIENCE PROGRAMS

JUNO

PROGRAM WEBSITE - *www.nasa.gov/mission_pages/juno/main/index.html*

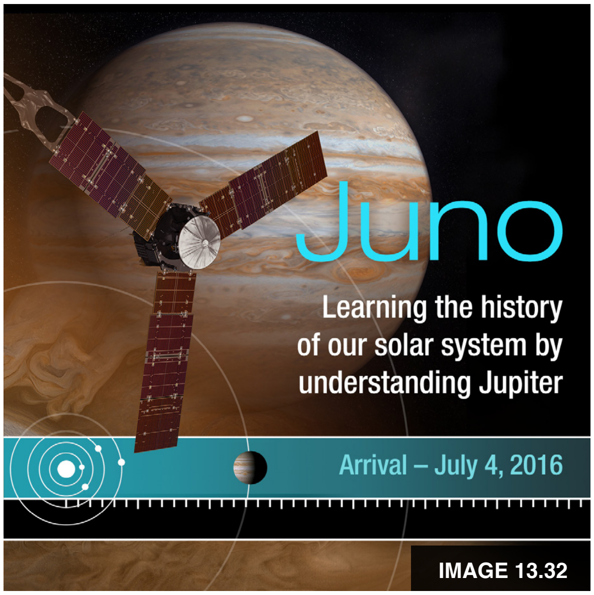


IMAGE 13.32

SHORT DESCRIPTION

Juno will conduct an in-depth study of Jupiter, the most massive planet in the solar system. Juno's instruments will seek information from deep in Jupiter's atmosphere, enabling scientists to understand the fundamental processes of the formation and early evolution of the solar system. Juno successfully launched on August 5, 2011, as scheduled and within the budget allocated for development of this mission, and arrived at Jupiter to begin science operations on July 4, 2016. Juno is the first solar-panel powered spacecraft to orbit the giant planet.

During its 16-month science operations mission, Juno, with the first-ever polar orbit of Jupiter, will sample Jupiter's full range of latitudes and longitudes. From its polar perspective, Juno combines remote sensing observations to explore the polar magnetosphere and determine what drives Jupiter's remarkable auroras. Juno has an onboard camera to produce images and it will provide unique opportunities to engage the next generation of scientists.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Begin multiple 14-day science orbits in FY 2017.
- End prime mission and de-orbit into Jupiter in FY 2018.

PARTNER OVERVIEW

- **NASA Center(s):** GSFC, MSFC, KSC, JPL-FFRDC
- **Federal Agencies:** N/A
- **International:** Italian Space Agency (ASI)
- **Academia:** Applied Physics Laboratory, University of Iowa
- **Industry:** Lockheed Martin, Malin Space Science Systems, Southwest Research Institute

JUPITER EUROPA MISSION

PROGRAM WEBSITE *- https://www.nasa.gov/europa*

SHORT DESCRIPTION

Jupiter's moon Europa is believed to have the largest known ocean in the solar system, and is one of the most likely places to find current life beyond Earth. For over fifteen years NASA has developed concepts to explore Europa and determine if it is habitable based on characteristics of its vast oceans (twice the size of all of Earth's oceans combined), the ice surface – ocean interface, the chemical composition of the intriguing, irregular brown surface areas, and the current geologic activity providing energy to the system.

After thorough investigation of concept options, NASA has initiated the Phase A study of a multiple flyby mission that delivers the most science for the least cost and risk of all the concepts studied. The flyby concept can take advantage of solar power and requires no new technology development, despite the harsh radiation environment that the spacecraft will encounter during the flybys.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Complete the Systems Readiness and Mission Design Reviews in FY 2017.
- Complete the Preliminary Design Review in FY 2019.
- Complete the Critical Design Review in FY 2020.

PARTNER OVERVIEW

- **NASA Center(s):** JPL-FFRDC, MSFC
- **Federal Agencies:** N/A
- **International:** N/A
- **Academia:** Applied Physics Laboratory, Arizona State University, University of Colorado, University of Texas
- **Industry:** Ball Aerospace, Southwest Research Institute

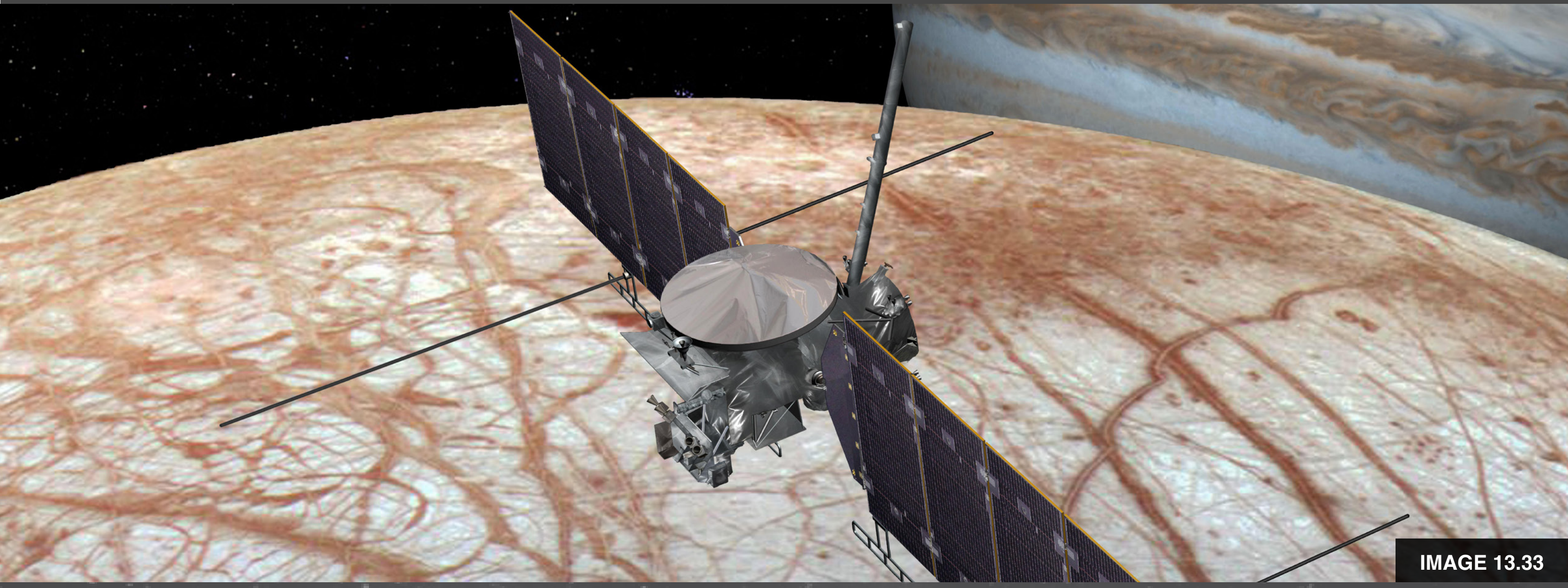


IMAGE 13.33

MARS ROVER 2020

PROGRAM WEBSITE *- http://mars.jpl.nasa.gov/mars2020*

IMAGE 13.34

SHORT DESCRIPTION

The Mars 2020 science rover mission addresses high-priority goals for planetary science, and it is the essential next step in an evolving long-term effort of Mars exploration that will ultimately involve human exploration. The mission will build upon many discoveries from the Mars Curiosity rover and the two Mars Exploration Rovers, Spirit and Opportunity, by advancing our understanding of Mars's potential as a habitat for past or present life.

The Mars 2020 rover will seek signs of past life on Mars, collect and store a set of samples for potential return to Earth in the future, and test new technology to benefit future robotic and human exploration of Mars. The mission will also deploy new capabilities developed through investments by NASA's Space Technology Mission Directorate, Human Exploration and Operations Mission Directorate, and contributions from international partners.

The Mars 2020 mission is planned to launch in July 2020, land on Mars in February 2021, and spend at least one Mars year (two Earth years) exploring the landing site region. The mission uses much of the design of the highly successful Mars Science Laboratory/Curiosity rover, which has been exploring Mars since 2012. The new rover will carry more sophisticated, upgraded hardware and new instruments to conduct geological assessments of the rover's landing site, determine the potential habitability of the environment, and search for signs of ancient Martian life. To minimize costs and risks, NASA will use a proven landing system and rover chassis design as much as possible, while still delivering a highly capable rover. The Mars 2020 rover is carrying a competitively selected science and technology instrument payload of seven instruments. NASA chose five of those instruments to provide the clearest possible measurements for seeking possible signs of ancient life (potential "biosignatures") on Mars over its long, 4.6 billion-year history. NASA chose the remaining two instruments to assess environmental hazards and natural resources for future human exploration. Additionally, scientists will use the instruments on board the rover to identify and collect samples of rock and soil, encase them in sealed tubes, and leave them on the surface of Mars for potential return to Earth by a future mission.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Complete the Critical Design Review in FY 2017.
- Select the landing site in FY 2018.
- Launch in FY 2020.
- Land on Mars in FY 2021.

PARTNER OVERVIEW

- **NASA Center(s):** JPL - FFRDC
- **Federal Agencies:** Department of Energy
- **International:** Norwegian Defense Research Establishment, Spanish Center of Astrobiology, Spanish National Institute of Aerospace Technology, French National Centre for Space Studies
- **Academia:** Arizona State University, Massachusetts Institute of Technology
- **Industry:** Lockheed Martin

PLANETARY SCIENCE PROGRAMS

NEW FRONTIERS AND DISCOVERY PROGRAMS

PROGRAM WEBSITE - *https://discoverynewfrontiers.nasa.gov/index.cfml*
PROGRAM WEBSITE - *http://discovery.nasa.gov/index.cfml*

IMAGE 13.35

SHORT DESCRIPTION

NASA is in the process of conducting two competitions for small and medium-class Principal Investigator-led planetary missions.

The New Frontiers program explores our solar system with medium-class spacecraft missions. Within the New Frontiers program, possible mission destinations and the science goals for each competitive opportunity are limited to specific science targets announced for the competition. The program is currently comprised of three missions, all in operations: New Horizons, Juno, and OSIRIS-REx.

NASA's Discovery program supports innovative, relatively low-cost, competitively selected planetary science missions. Discovery provides scientists the opportunity to identify innovative ways to unlock the mysteries of the solar system through missions to explore the planets, their moons, and small bodies such as comets and asteroids. The Discovery program currently has two operational spacecraft, Lunar Reconnaissance Orbiter (LRO) and Dawn, and one flight mission in development: the Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight). The program has also developed and delivered the Strofio instrument as a part of ESA's BepiColombo mission to Mercury.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Announce the results of the Discovery downselect process in FY 2017.
- Release the New Frontiers announcement of opportunity in FY 2017.

PARTNER OVERVIEW

- **NASA Center(s):** MSFC, GSFC, JPL - FFRDC
- **Federal Agencies:** N/A
- **International:** N/A
- **Academia:** Applied Physics Laboratory
- **Industry:** N/A

PLANETARY DEFENSE COORDINATION OFFICE (PDCO)

PROGRAM WEBSITE *- https://www.nasa.gov/planetarydefense*

SHORT DESCRIPTION

NASA's Planetary Defense Coordination Office (PDCO) is managed in the Planetary Science Division of the Science Mission Directorate at NASA Headquarters in Washington, D.C. PDCO is responsible for:

- Ensuring the early detection of potentially hazardous objects (PHOs) – asteroids and comets whose orbits are predicted to bring them within 0.05 Astronomical Units of Earth, and of a size large enough to reach Earth's surface – that is, greater than perhaps 30 to 50 meters;
- Tracking and characterizing PHOs and issuing warnings about potential impacts;
- Providing timely and accurate communications about PHOs; and
- Performing as a lead coordination node in U.S. Government planning for response to an actual impact threat.

The PDCO relies on data from projects supported by NASA's Near-Earth Object Observations (NEOO) Program. The PDCO also coordinates NEO observation efforts conducted at ground-based observatories sponsored by the National Science Foundation and space situational awareness facilities of the United States Air Force. In addition to finding, tracking, and characterizing PHOs, NASA's planetary defense goals include developing techniques for deflecting or redirecting PHOs, if possible, that are determined to be on an impact course with Earth. In the event that deflection or redirection is not possible, the PDCO is responsible for providing expert input to the Federal Emergency Management Agency for emergency response operations should a PHO be on an impact course or actually impact the Earth.

In the event that experts find a PHO and predict a possible, probable, or certain impact with Earth, the PDCO is responsible for providing timely and accurate information to the Government, the media, and the public. The Minor Planet Center is tasked with notifying observers worldwide about PHOs so they can conduct timely follow-up observations. The Jet Propulsion Laboratory's Center for NEO Studies (CNEOS) analyzes data collected on PHOs, predicts future orbits, and calculates impact probabilities. CNEOS will use new data to refine its predictions of the PHO's orbit. If a PHO poses a significant chance of impacting Earth (that is, greater than 1 percent over the next 100 years), the PDCO prepares notification messages for the NASA Administrator to send to the Executive Office of the President, the U.S. Congress, and other Government organizations.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Begin preliminary design for Asteroid Impact and Deflection Assessment-Double Asteroid Redirection Test (AIDA-DART) in FY 2017.
- Conduct Asteroid Impact Table Top Exercise #3 with FEMA Region 9 in FY 2017.
- Release the findings from the NEO Science Definition Team 2016 in FY 2017.
- Approve and release the National Near-Earth Object Preparedness Strategy (Strategy) and the accompanying National Near-Earth Object Preparedness Action Plan (Action Plan) in FY 2017.
- Hold the 5th International Planetary Defense Conference in Tokyo, Japan in FY 2017.

PARTNER OVERVIEW

- **NASA Center(s):** JPL - FFRDC, ARC, Glen Research Center (GRC), GSFC, MSFC, JSC
- **Federal Agencies:** Federal Emergency Management Agency (FEMA), National Nuclear Security Administration (NNSA), National Oceanic and Atmospheric Administration, Office of Science and Technology Policy (OSTP), United States Air Force
- **International:** European Space Agency, European Southern Observatory, Japanese Space Agency, Korean Astronomy and Space Science Institute, Mexican National Institute of Astrophysics, Optics and Electronics, Romanian Space Agency, Russian Academy of Sciences, United Nations Office of Outer Space Affairs
- **Academia:** Johns Hopkins University-Applied Physics Laboratory, Massachusetts Institute of Technology Lincoln Laboratory, University of Arizona, University of Hawaii, University of Maryland, Smithsonian Astrophysical Observatory
- **Industry:** N/A

PLANETARY SCIENCE PROGRAMS

MARS HUMAN LANDING SITES

SHORT DESCRIPTION

The United States has amazing robotic spacecraft and rovers at Mars which are dramatically increasing our knowledge about the Red Planet and paving the way for future human explorers.

Because a number of these assets are past their original design lifetimes and given that picking a human landing site on a new world involves significant unknowns, NASA began the process in 2015 of selecting where humans will land on Mars.

The goal of this effort is to select a landing site that maximizes the science that can be achieved with human beings on Mars while providing access to critical local resources needed to sustain these crews (thereby minimizing how much costly mass has to be sent from Earth to Mars).

A secondary goal of the landing site study is to determine what future reconnaissance will be needed at Mars to ultimately pick the landing site and to support human operations there.

The Mars Landing Sites Study is a joint effort of the Human Exploration and Operations Mission Directorate and the Science Mission Directorate. For a short video overview on the effort, visit the link below: ***VIDEO OVERVIEW*** - *https://www.youtube.com/watch?v=_lqiEpkIFDU&feature=youtu.be*

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Complete the six projects that will provide critical data to prepare for the next Mars Human Landing Sites workshop in FY 2017.
- Hold the second human landing site workshop in FY 2017.
- Down-select to five potential human landing sites in FY 2019.

PARTNER OVERVIEW

- **NASA Center(s):** ARC, GRC, GSFC, JSC, KSC LaRC, JPL – FFRDC
- **Federal Agencies:** N/A
- **International:** N/A
- **Academia:** Arizona State University, Brown University, Colorado School of Mines, George Mason University, Georgia Institute of Technology, Harvard University, Massachusetts Institute of Technology, Missouri University of Science and Technology, Purdue University, University of Hawaii, University of Houston, University of Florida, University of New Mexico, University of Texas, University of Vermont, Western Washington University
- **Industry:** Boeing, Lockheed Martin, Southwest Research Institute

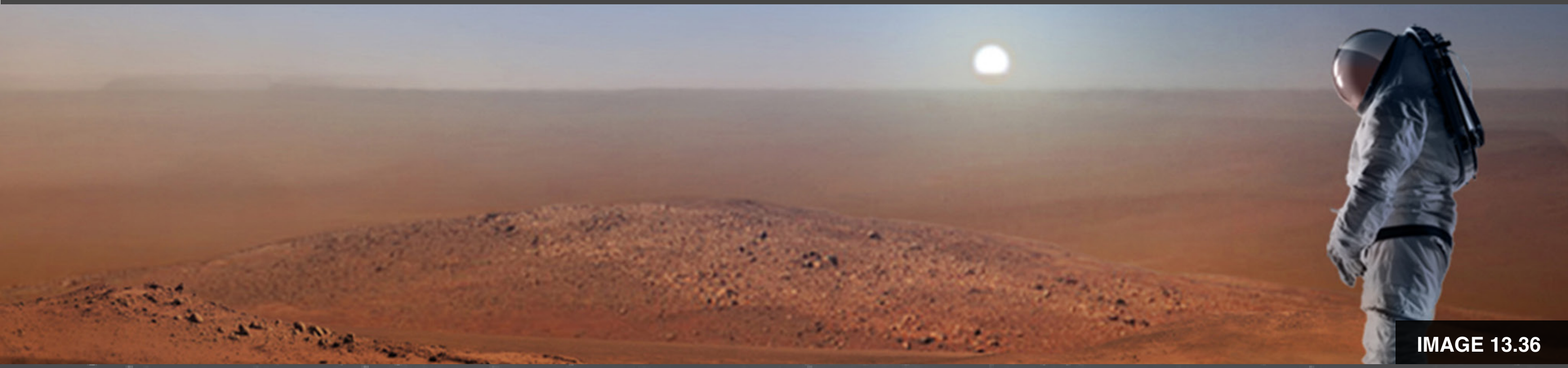


IMAGE 13.36

ASTROPHYSICS MISSIONS

CHANDRA X-RAY OBSERVATORY (CXO)

PROGRAM WEBSITE *- http://chandra.harvard.edu/index.html*

IMAGE 13.37

SHORT DESCRIPTION

NASA's Chandra X-ray Observatory (CXO) is a space telescope designed to detect X-ray emission from very hot regions of the Universe such as exploded stars, clusters of galaxies, and matter around black holes. As an X-ray mission, CXO provides information on the hottest and most energetic objects in the sky, both near and far. This capability has allowed a broad range of astrophysical studies of galaxies, stars and planets (including exoplanets), as well as exploration of the behavior of matter and energy above nuclear densities. X-ray emissions can only be studied from space because the Earth's atmosphere blocks incoming x-rays.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Compile a broad range of catalogs and legacy data to guide future studies in all branches of astronomy and astrophysics, with emphasis on the study of the origin and evolution of supermassive black holes and their host galaxies.

PARTNER OVERVIEW

- **NASA Center(s):** MSFC
- **Federal Agencies:** N/A
- **International:** N/A
- **Academia:** Smithsonian Astrophysical Observatory, in addition researchers from hundreds of academic institutions are funded to conduct research using Chandra
- **Industry:** N/A

ASTROPHYSICS MISSIONS

HUBBLE SPACE TELESCOPE (HST) OPERATIONS

PROGRAM WEBSITE - *https://www.nasa.gov/mission_pages/hubble/main/index.html*

IMAGE 13.38

SHORT DESCRIPTION

The Hubble Space Telescope (HST) is a cooperative program of the European Space Agency (ESA) and the National Aeronautics and Space Administration (NASA) to operate a long-duration space-based observatory for the benefit of the international astronomical community. HST is operational since the 1990s, and had numerous servicing missions. HST is a 2.4-meter reflecting telescope, which was deployed in low-Earth orbit (600 kilometers) by the crew of the space shuttle Discovery (STS-31) on April 25, 1990, and carries a suite of instruments for multi-wavelength observations in the optical, Ultraviolet, IR and Far IR portions of the electromagnetic spectrum.

HST was designed to address the most compelling astrophysics questions about the origin and evolution of our Universe. During its long lifetime it has observed a pantheon of astrophysical sources – from nearby and distant galaxies to supernovae and Solar System bodies. One of the major achievements of HST is the Hubble Deep Field, a very deep observation of a small region in the constellation Ursa Major, which provided an unprecedented view of the young Universe.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- The Space Telescope Science Institute (STScI), which manages Hubble's science program, will select Cycle 25 science observations. Similar to other recent competitions for Hubble observing time, NASA expects requested observational orbits to outnumber the available orbits by a factor of six to one, indicating that Hubble remains one of the world's preeminent astronomical observatories.

PARTNER OVERVIEW

- **NASA Center(s):** GSFC
- **Federal Agencies:** N/A
- **International:** European Space Agency (ESA)
- **Academia:** Space Telescope Science Institute (STScI)
- **Industry:** N/A

ASTROPHYSICS PROGRAMS

JAMES WEBB SPACE TELESCOPE (JWST)

PROGRAM WEBSITE - *http://www.jwst.nasa.gov/*

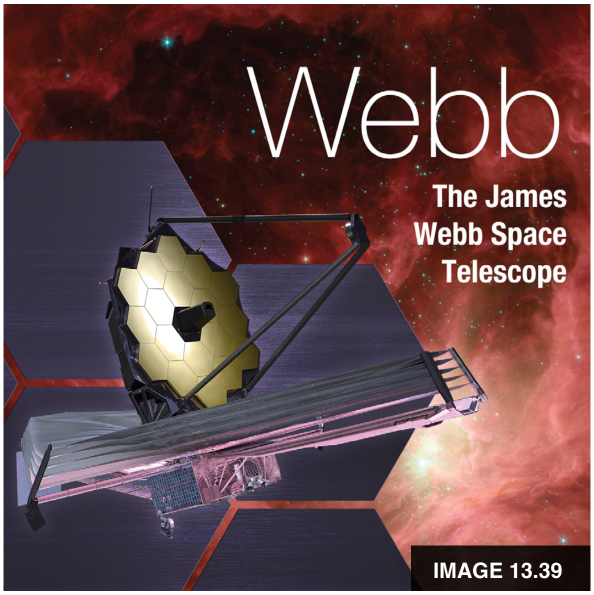


IMAGE 13.39

SHORT DESCRIPTION

The James Webb Space Telescope (JWST) is a NASA strategic mission to study many problems in astronomy and astrophysics as diverse as imaging the earliest stars and galaxies to form after the Big Bang to the remote examination of the atmospheres of exoplanets. JWST was re-baselined on September 2011 following the report from the congressionally-initiated Independent Comprehensive Review Panel that recommended several changes in how the Program was managed and funded. As such, JWST is currently managed in a separate program office within SMD and will returns to Astrophysics Division management upon commissioning. JWST is expected to launch in 2018. JWST is an excellent complement to and scientific successor of the Hubble Space Telescope (HST), extending beyond Hubble's capabilities by virtue of its larger mirror and by looking into the near and mid-infrared spectrum, where the highly red-shifted early universe can be better observed.

JWST is optimized for infrared astronomy, with some capability in the visible range. It will have a 6.5-meter-diameter, segmented, adjustable primary mirror. JWST's instruments are:

- Near Infrared Camera (NIRCam);
- Mid Infrared Instrument (MIRI);
- Near Infrared Spectrograph (NIRSpec); and
- Fine Guidance Sensor (FGS)/Near Infrared Imager and Slitless Spectrograph (NIRISS).

NIRSpec and MIRI are collaborations with the European Space Agency (ESA), and FGS/NIRISS is being provided by the Canadian Space Agency. The telescope is scheduled to launch in 2018. Its operational location is the L2 Lagrange point. The JWST Ground Operations, Science Support Center, and archives will be at Space Telescope Science Institute (STScI) in Baltimore, MD.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Complete cryo-vacuum testing of the Optical Telescope Element and Integrated Science at Johnson Space Center in FY 2017.
- Complete Integration and Testing of entire JWST Observatory in FY 2018.
- Launch JWST and begin 5-year primary mission in FY 2019.

PARTNER OVERVIEW

- **NASA Center(s):** GSFC, JSC
- **Federal Agencies:** N/A
- **International:** Canadian Space Agency (CSA), European Space Agency (ESA)
- **Academia:** Space Telescope Science Institute
- **Industry:** Northrop-Grumman Aerospace Systems

ASTROPHYSICS MISSIONS

KEPLER

PROGRAM WEBSITE *- http://kepler.nasa.gov/*

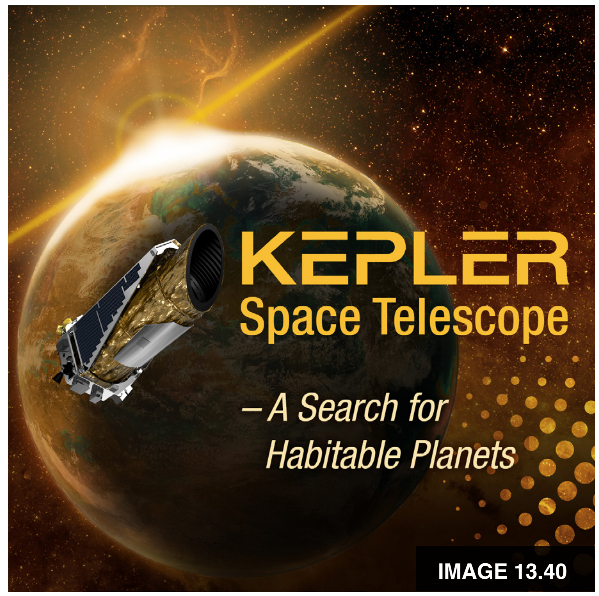


IMAGE 13.40

SHORT DESCRIPTION

The Kepler mission is a Discovery Program mission, and is the first NASA mission aimed specifically at trying to find Earth-sized planets orbiting stars similar to our own Sun. Kepler, launched in March 2009, was specifically designed to survey a large number of distant stars in one region of the Milky Way galaxy to detect and characterize rocky planets in or near the "habitable zone" of their host star. The habitable zone encompasses the distances from a star where liquid water can exist on a planet's surface.

Kepler observations have resulted in numerous scientific discoveries and the project has released a substantial data set to the astronomical community. The Kepler prime mission was completed in November 2012. NASA accepted the recommendation of the 2012 Senior Review to extend the mission through 2013, at which time component failures ended the original Kepler mission.

In 2014, the repurposed Kepler spacecraft began its Kepler 2 (K2) mission, surveying the Ecliptic with science goals of high value exoplanet discovery (to aid JWST follow-up), many types of astrophysics, and precursor high-impact science of microlensing events and supernovae, setting the stage for WFIRST. K2 is still in operation, having been granted a mission extension by the 2016 Senior Review.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Complete observations and publish results of the more than 100 microlensing events and the joint observations from ground-based telescopes.
- Complete observations of the Galactic Center during the upcoming Campaign 11.
- Continue to detect the onset of supernovae events that will provide robust test to understand their progenitors and explosion mechanisms.
- Complete final close-out data products to be archived for the community.

PARTNER OVERVIEW

- **NASA Center(s):** Ames Research Center (ARC)
- **Federal Agencies:** N/A
- **International:** N/A
- **Academia:** N/A
- **Industry:** N/A

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA)

PROGRAM WEBSITE - *https://www.nasa.gov/mission_pages/SOFIA/index.html*

IMAGE 13.41

SHORT DESCRIPTION

SOFIA is a unique airborne astronomical observatory that provides scientific data that are impossible to obtain from even the largest ground-based telescopes, enabling scientific exploration of a wide range of astronomical phenomena. Such studies include star birth and death and the formation of new solar systems, the development of life-enabling molecules such as water and of their incorporation into planets, the role of dust and complex molecules, and observations of the planets, comets and asteroids in our solar system to better understand Earth's own evolution. Detecting infrared light emitted by these objects is possible only at high altitude (39,000-45,000 feet) where the obscuration by water vapor in the Earth's lower atmosphere is negligible. SOFIA is the only operating Far IR NASA mission and enables "Great Observatory" class science investigations through acquisition of images, spectroscopy, polarization measurements, and fast-speed photometry spanning four orders of magnitude in wavelength coverage.

NASA and the Deutches Zentrum für Luft- und Raumfahrt (DLR), Germany's Aerospace Research Center and Space Agency, together maintain and operate SOFIA, a Boeing 747SP aircraft that was modified to accommodate a 2.5 meter reflecting telescope. SOFIA became fully operational in 2014. The SOFIA program and science operations are conducted out of the NASA Ames Research Center. The modified Boeing 747SP airliner flies its missions from the NASA Armstrong Flight Research Center's Building 703 in Palmdale during what is anticipated to be a 20-year lifespan.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Complete a southern hemisphere deployment to New Zealand with a maximum duration of 7 weeks and involving up to three science instruments in FY 2017.
- Complete development of new generation infrared instruments and conduct science operations.
- Prepare senior review proposal for extended operations.

PARTNER OVERVIEW

- **NASA Center(s):** ARC, GSFC, Armstrong Flight Research Center (AFRC), JPL-FFRDC
- **Federal Agencies:** National Science Foundation (NSF)
- **International:** German SOFIA Institute, German Space Agency (DLR), Max Planck Institut, New Zealand Ministry of Education, University of Stuttgart
- **Academia:** Cornell University, Lowell Observatory, University of California-Davis, University of California-Los Angeles, Universities Space Research Association
- **Industry:** N/A

ASTROPHYSICS MISSIONS

WIDE FIELD INFRARED SURVEY TELESCOPE (WFIRST)

PROGRAM WEBSITE - *http://wfirst.gsfc.nasa.gov/*

IMAGE 13.42

SHORT DESCRIPTION

WFIRST is a NASA observatory designed to perform wide field imaging and surveys of the sky at near-infrared wavelengths to address key questions in astrophysics. WFIRST is the highest priority large space mission in the New Worlds, New Horizon 2010 Decadal Survey of Astronomy and Astrophysics, so ranked because of its broad science capability including conducting definitive measurements of dark energy and cosmology, greatly expanding on the survey of exoplanet demographics begun by Kepler, and providing Hubble-quality wide-field imaging capability for astronomy in the next decade.

The current design of the mission makes use of an existing 2.4m telescope, which is the same size as the Hubble Space Telescope. The Wide Field Instrument will provide a field of view of the sky that is 100 times larger than images provided by Hubble. The Coronagraphic Instrument will enable astronomers to detect and measure properties of planets and planetary atmospheres in other solar systems. Using this instrument suite, WFIRST will achieve the following top level goals:

- Characterize the history of cosmic acceleration and structure growth in the universe;
- Understand how planetary systems form and evolve and determine the prevalence of planets in the colder outer regions;
- Understand the compositions and atmospheric constituents of a variety of planets around nearby stars and determine the properties of debris disks around nearby stars; and
- Provide community access to cutting edge scientific research capability via a peer-reviewed Guest Observer program.

WFIRST is a Category 1, Class B mission in Phase A, preparing for a launch in the mid-2020s. The Project continues its formulation activities, including design refinements, trade studies, science requirements definition, technology maturation, industry studies, international contribution coordination, science simulations, and development planning.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Complete all component technology development (up to Technology Readiness Level 5) in FY17.
- Complete System Requirements Review and Mission Design Review in FY 2017.

PARTNER OVERVIEW

- **NASA Center(s):** GSFC, JPL - FFRDC
- **Federal Agencies:** Naval Research Laboratory (ICON)
- **International:** University of Liège
- **Academia:** University of California-Berkeley (ICON), University of Central Florida (GOLD), University of Colorado/ Laboratory for Atmospheric and Space Physics (GOLD), University of Texas-Dallas (ICON)
- **Industry:** Orbital-ATK (ICON), SES Government Solutions (GOLD)

HELIOPHYSICS PROGRAMS

SOLAR PROBE PLUS (SPP)

PROGRAM WEBSITE - https://science.nasa.gov/missions/solar-probe/

IMAGE 13.43

SHORT DESCRIPTION

Solar Probe Plus (SPP) will be an extraordinary and historic mission, exploring what is arguably the last region of the solar system to be visited by a spacecraft, the Sun's outer atmosphere or corona as it extends out into space. This Living With a Star (LWS) mission will use seven Venus flybys over nearly seven years to gradually shrink its orbit around the Sun, coming as close as 3.7 million miles (5.9 million kilometers) to the Sun, well within the orbit of Mercury and about eight times closer than any spacecraft has come before. During its unprecedented close-up study of the Sun, SPP will endure 2600-degrees Fahrenheit, supersonic solar particles, and intense radiation. This mission has been the top priority of the heliophysics science community for over five decades. The mission is scheduled to launch in 2018.

The mission has five science investigations which were selected competitively from the scientific community.
READ MORE - http://solarprobe.jhuapl.edu/Spacecraft/index.php#Instruments

SPP has three science objectives:

- Trace the flow of energy that heats and accelerates the solar corona and solar wind.
- Determine the structure and dynamics of the plasma and magnetic fields at the sources of the solar wind.
- Explore mechanisms that accelerate and transport energetic particles.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Deliver the final versions of flight software, flight thermal protection system, and flight solar arrays in FY 2017.
- Complete integration and testing and ship to Cape Canaveral launch site in FY 2018.
- Launch in FY 2018.
- Commence prime mission in FY 2019.

PARTNER OVERVIEW

- **NASA Center(s):** GSFC, JPL - FFRDC
- **Federal Agencies:** Naval Research Laboratory (NRL)
- **International:** N/A
- **Academia:** Applied Physics Laboratory, Smithsonian Astrophysical Observatory, University of California-Berkeley
- **Industry:** Ball Aerospace, Lockheed Martin, Southwest Research Institute

SOLAR ORBITER COLLABORATION (SOC)

PROGRAM WEBSITE - *https://science.nasa.gov/missions/solar-orbiter*

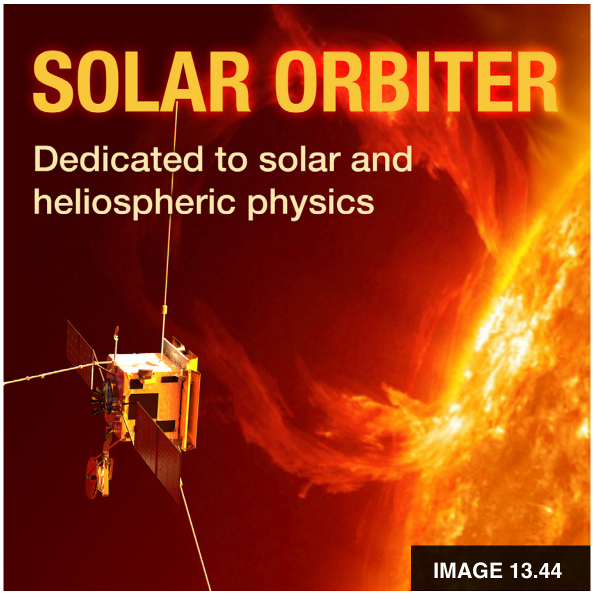


IMAGE 13.44

SHORT DESCRIPTION

The NASA and ESA SOC mission will provide measurements that will give NASA better insight on the evolution of sunspots, active regions, coronal holes, and other solar features and phenomena. The instruments will explore the near-Sun environment to improve our understanding of the origins of the solar wind streams and the heliospheric magnetic field; the sources, acceleration mechanisms, and transport processes of solar energetic particles; and the evolution of coronal mass ejections (CMEs) in the inner heliosphere. To achieve these objectives, SOC will make *in situ* measurements of the solar wind plasma, fields, waves, and energetic particles. SOC will also make imaging/spectroscopic observations. SOC will provide close-up views of the Sun's polar regions and far side. SOC will tune its orbit to the direction of the Sun's rotation to allow the spacecraft to observe one specific area for much longer than is currently possible.

ESA provides the spacecraft and operations, the ESA member states provide the majority of the instruments, and NASA provides the launch vehicle and two science investigations/instruments: the Solar Orbiter Heliospheric Imager (SoloHI) and the Heavy Ion Sensor (HIS). In return for its contributions, NASA will have access to the entire science mission data set.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Deliver flight models of both the NASA-provided science instruments (SoloHI and HIS) to ESA in FY 2017.
- Launch from Kennedy Space Center in FY 2019 and begin its prime mission.

PARTNER OVERVIEW

- **NASA Center(s):** GSFC
- **Federal Agencies:** Naval Research Laboratory
- **International:** European Space Agency
- **Academia:** N/A
- **Industry:** Southwest Research Institute

MAGNEOTSPHERIC MULTISCALE MISSION (MMS)

PROGRAM WEBSITE - *https://mms.gsfc.nasa.gov/index.html*

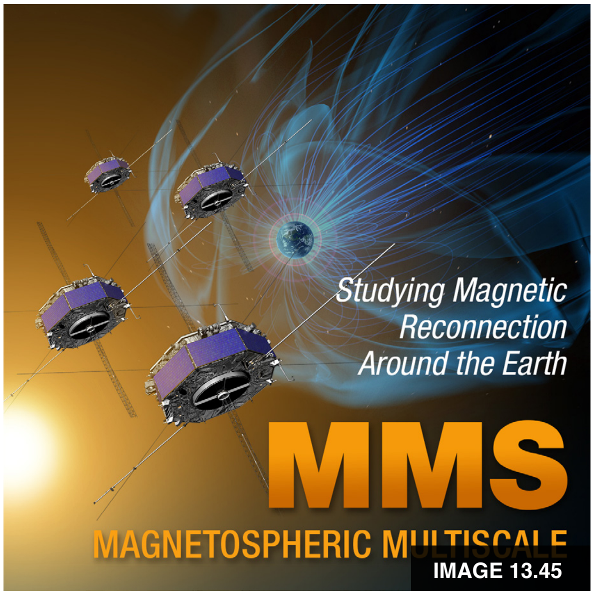


IMAGE 13.45

SHORT DESCRIPTION

MMS relies on four identical spacecraft, each with a set of 11 instruments consisting of 25 sensors. The four spacecraft fly in an adjustable, pyramid formation that enables them to observe the 3-dimensional structure of magnetic reconnection as they skim the magnetopause boundary and magnetotail. Four spacecraft give MMS the necessary perspectives to fully resolve this poorly understood, fundamental process, which not only connects and disconnects Earth and Sun, explosively releasing energy, but is also a major source of space weather.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

MMS consists of four spacecraft in specified formation in elliptical Earth orbit. The mission has conducted a near-Earth phase for measuring magnetic reconnection at the sun-facing side of the magnetosphere, and will in the upcoming period raise maximum Earth distance to reach into the magnetic reconnection region in the magnetotail. It specifically focuses on the behavior of electrons during reconnection. During the second phase it will also obtain high-resolution measurements of the solar wind.

PARTNER OVERVIEW

- **NASA Center(s):** GSFC
- **Federal Agencies:** N/A
- **International:** Japanese Aerospace Exploration Agency, Austrian Academy of Science, École Polytechnique, Centre d'Etude Spatiale des Rayonnements, Swedish National Space Board
- **Academia:** University of New Hampshire, Johns Hopkins University, The Aerospace Corporation, Rice University, University of Iowa, University of Colorado, University of California
- **Industry:** Southwest Research Institute, Lockheed Martin

VOYAGER INTERSTELLAR MISSION

PROGRAM WEBSITE - *http://voyager.jpl.nasa.gov*

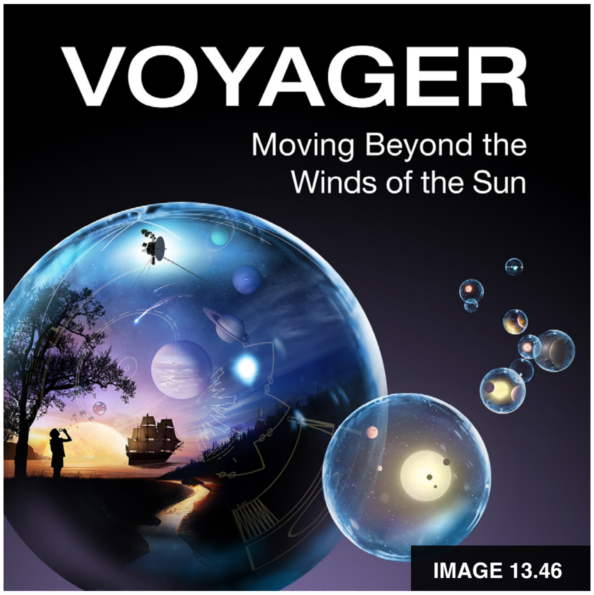


IMAGE 13.46

SHORT DESCRIPTION

The Voyager Interstellar Mission explores the interaction of the outer reaches of the solar wind with the winds from other stars, the interstellar medium (LISM). Of the two spacecraft, Voyager 1 is the farthest away, at more than 13 billion miles (20 billion km), and since 2012 explores the interstellar medium directly. Voyager 2, which has visited all four solar system gas giants, Jupiter, Saturn, Uranus and Neptune, is the longest continuously operating spacecraft, is still immersed in the outer reaches of the solar wind. Both provide unique observations on their way outward of the unexplored space environment at record-setting distances.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

Voyager 2 may cross the Heliopause in this time frame. The Heliopause location likely fluctuates in response to the solar wind. It forms the most critical barrier that shields the Earth and other planets from high fluxes of cosmic rays. Voyager 2 will then start exploring interstellar space in tandem with Voyager 1. Both will continue detecting large-scale disturbances from the sun and help understanding of physical processes at the vast region that separates solar material from that of other stars.

PARTNER OVERVIEW

- **NASA Center(s):** JPL, GSFC
- **Federal Agencies:** N/A
- **International:** N/A
- **Academia:** Caltech, University Iowa, Johns Hopkins University
- **Industry:** N/A

HELIOPHYSICS PROGRAMS

HELIOPHYSICS EXPLORER PROGRAM

***PROGRAM WEBSITE** - http://explorers.gsfc.nasa.gov/*

SHORT DESCRIPTION

The Heliophysics Explorer Program provides frequent flight opportunities for world-class scientific investigations on focused and timely science topics. Explorers use a suite of smaller, fully competed missions that address these topics to complement the science of strategic missions of the other Heliophysics mission lines – the Living With Star and Solar Terrestrial Probes programs. Competitive selections ensure accomplishment of the most current and best science.

The Explorers Program provides several classes (Medium Explorers-MIDEX and Small Explorers-SMEX) of flight opportunities to accomplish the goals of the science program. The 2011 NASA AO introduced a new class of flight opportunity, the Explorers (EX) missions, in response to the currently available expendable launch vehicles. EX missions fall between the SMEX and MIDEX class missions. The Explorer Program enables NASA to increase the number of flight opportunities in response to recommendations from the scientific community. Awarded missions utilize one of the several, lower-cost expendable launch vehicles available through NASA's Launch Services Program.

Explorer Missions of Opportunity (MO) are smaller investigations, typically an instrument, characterized as being part of a host space mission, sub-orbital flight, small complete missions, and new science investigations using existing spacecraft or ISS-attached payloads.

Currently, one Explorer mission, the Ionospheric Connections Explorer (ICON), and one Mission of Opportunity, Global-scale Observations of Limb and Disk (GOLD), are in implementation.

ICON is a single spacecraft mission dedicated to understanding neutral-ion coupling in the Earth's low-latitude upper atmosphere, also known as the thermosphere, and ionosphere. It will resolve both long-standing and newly emerging questions about the mechanisms that control the daily development of plasma in Earth's space environment.

IMAGE 13.47

IMAGE 13.48

The GOLD investigation will perform unprecedented imaging of the Earth's thermosphere and ionosphere from geostationary orbit. It is pioneering a new pathway for NASA Science Mission Directorate, as it will be the first hosted NASA science payload on a commercial satellite. GOLD will answer fundamental scientific questions about how the thermosphere/ionosphere system responds to geomagnetic storms, solar radiation, and upward propagating waves and tides.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Select Small Explorer mission concepts for competitive Phase A study in FY 2017.
- Complete ICON integration and test activities in FY2017.
- Launch ICON in early FY 2018.
- Launch GOLD in FY 2018.

PARTNER OVERVIEW

- **NASA Center(s):** GSFC
- **Federal Agencies:** Naval Research Laboratory (ICON)
- **International:** University of Liège
- **Academia:** University of California-Berkeley (ICON), University of Central Florida (GOLD), University of Colorado/ Laboratory for Atmospheric and Space Physics (GOLD), University of Texas-Dallas (ICON)
- **Industry:** Orbital-ATK (ICON), SES Government Solutions (GOLD)

JOINT AGENCY SATELLITE DIVISION MISSIONS

GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE-R (GOES-R) SERIES

PROGRAM WEBSITE *- http://www.goes-r.gov/*

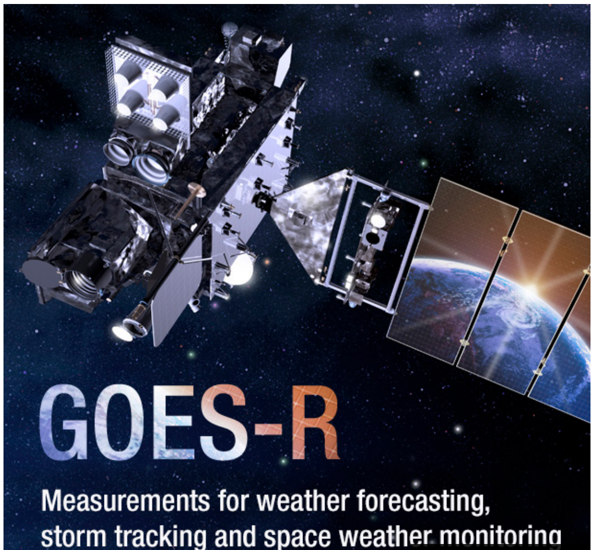


IMAGE 13.49

SHORT DESCRIPTION

The Geostationary Operational Environment Satellite-R (GOES-R) series (GOES-R, S, T, and U) is the next generation of National Oceanic and Atmospheric Administration (NOAA) geostationary satellites that will provide a major improvement in the quality, quantity and timeliness of data collected. GOES-R series will provide improved detection and observations of meteorological and solar phenomena that directly impact public safety, protection of property and economic health and development.

GOES-R will leverage its advanced spacecraft and instrument technology to support expanded detection of environmental phenomena, resulting in more timely and accurate weather forecasts and warnings; provide continuous imagery and atmospheric measurements of Earth's Western Hemisphere and space weather monitoring; and function as the primary tool for the detection and tracking of hurricanes and severe weather. The GOES-R series will continue the two-satellite system implemented by the current GOES series. The GOES-R series operational lifetime extends through December 2036.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Launch GOES-R and complete 6-month on-orbit checkout period in FY 2017.
- Launch GOES-S in FY 2018 and complete 6-month on-orbit checkout period in FY 2019.
- Launch GOES-T in FY 2019 and complete on-orbit checkout period in FY 2020.

PARTNER OVERVIEW

- **NASA Center(s):** GSFC
- **Federal Agencies:** National Oceanic and Atmospheric Administration
- **International:** N/A
- **Academia:** N/A
- **Industry:** N/A

JOINT AGENCY SATELLITE DIVISION MISSIONS

JOINT POLAR SATELLITE SYSTEM (JPSS)

PROGRAM WEBSITE - *https://jointmission.gsfc.nasa.gov/jpss.html*

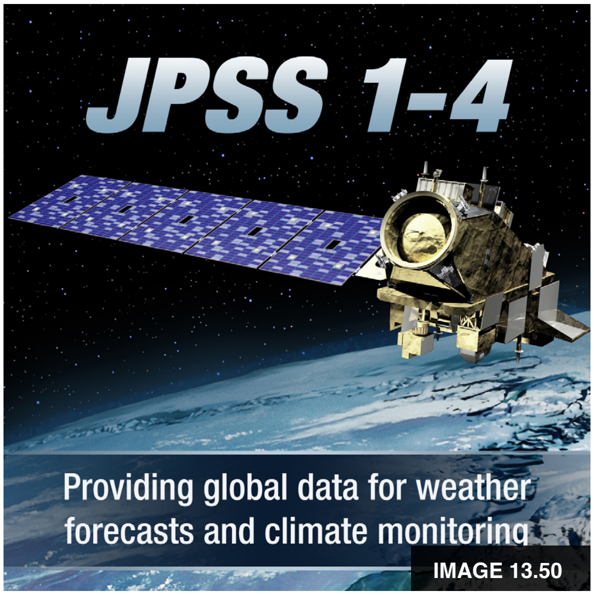


IMAGE 13.50

SHORT DESCRIPTION

The Joint Polar Satellite System (JPSS) is the next generation of National Oceanic and Atmospheric Administration (NOAA) polar orbiting environmental monitoring satellites and represents significant technological and scientific advancements in severe weather prediction and environmental monitoring. The JPSS mission will increase the accuracy and reliability of weather forecasting capabilities especially for severe weather and tropical cyclones, improve use of polar-orbiting satellite data for ocean and coastal applications, and continue and enhance our long-term environmental data sets to facilitate long term climate monitoring and prediction.

JPSS is set to deploy and operate through FY 2038. It consists of five satellites: the Suomi National Polar-orbiting Partnership (Suomi NPP), which launched in 2011, JPSS-1, JPSS-2, JPSS-3 and JPSS-4. The JPSS-1 satellite is currently in its environmental test phase.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Launch JPSS-1 from Vandenberg Air Force Base in FY 2017.
- Complete JPSS-1 nominal 90 day on-orbit checkout period in FY 2017.
- Complete JPSS-2 Mission Preliminary Design Review in FY 2017.
- Complete Key Decision Point C and establish Agency Baseline Commitment in FY 2017 for JPSS-3/4 Polar Follow-on (PFO).

PARTNER OVERVIEW

- **NASA Center(s):** GSFC
- **Federal Agencies:** National Oceanic and Atmospheric Administration
- **International:** N/A
- **Academia:** N/A
- **Industry:** N/A

SUBORBITAL RESEARCH PROGRAM

PROGRAM WEBSITE - *http://www.nasa.gov/centers/wallops/home*
PROGRAM WEBSITE - *https://airbornescience.nasa.gov*

SHORT DESCRIPTION

The Suborbital Research Program (SRP) enables fundamental scientific, technological, and educational investigations, and is characterized by frequent flight opportunities utilizing aircraft, balloons, sounding rockets, cubesats, suborbital reusable launch vehicles, and small International Space Station (ISS) payloads. These platforms support a wide variety of scientific objectives related to Earth science, heliophysics, planetary science, and astrophysics. Suborbital platforms can often provide data on much finer spatial and temporal scales than those achievable by on-orbit instruments, and they enable *in situ* measurements and active experiments that require waiting for appropriate geophysical conditions. The Suborbital research program enables:

- Cutting edge Earth and Space science
- Developing space technologies to enable new missions
- Promoting STEM and inspiring students through hands-on student training missions

The Program seeks to provide safe, low-cost, access to near space through a commitment to developing enabling technologies that are intended to extend the performance capabilities of the research carriers to support investigation requirements, as well as increase the Technology Readiness Level (TRL) of science instruments. The Program will also provide opportunities to train the next generation of scientists and engineers, and to promote science, technology, engineering and mathematics (STEM) through providing hands-on educational training activities.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Sounding Rockets will launch 15-20 investigations each year.
- Balloons will launch 10-16 investigations each year.
- Aircrafts will fly 2000-4000 investigation flight hours each year.
- Special projects will launch 1-2 investigations each year.

PARTNER OVERVIEW

- **NASA Center(s):** GSFC, ARC, GRC, JSC, LaRC
- **Federal Agencies:** Multiple
- **International:** N/A
- **Academia:** Multiple
- **Industry:** Multiple

DIRECTORATE-WIDE PROGRAMS

TECHNOLOGY DEVELOPMENT

PROGRAM WEBSITE *- https://science.nasa.gov/technology*
PROGRAM WEBSITE *- https://techport.nasa.gov*

SHORT DESCRIPTION

Each of the four SMD science divisions develop fundamental science questions upon which to base future research and mission programs. Often the breakthrough science required to answer these questions requires significant technological innovation—e.g., instruments or platforms with capabilities beyond the current state of the art. SMD's targeted technology investments fill technology gaps, enabling NASA to build the challenging and complex missions that accomplish groundbreaking science. The Directorate works to ensure that NASA actively identifies and invests in the right technologies at the right time to enable the Agency's science program. SMD technology development is part of a comprehensive Agency-wide strategy that involves coordination with the NASA Chief Technologist and other Agency mission directorates. This coordination helps ensure that crosscutting technology development needs are identified across the Agency and that there is optimal return on investments to fulfill those needs. SMD accomplishes technology development through technology programs established in each of its four science divisions.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Complete joint SMD/STMD study on Small Satellites.
- Develop new opportunity to mature SMD technologies through the STMD Technology Demonstration Missions Program.
- Infuse and develop technologies in new missions.
- Support a Small Spacecraft Framework for the Future.

PARTNER OVERVIEW

- **NASA Center(s):** JPL - FFRDC, GRC, LaRC, MSFC, JSC, GSFC, KSC, ARC, Wallops Flight Facility (WFF)
- **Federal Agencies:** N/A
- **International:** N/A
- **Academia:** Many partners
- **Industry:** Many partners

DIRECTORATE-WIDE PROGRAMS

SCIENCE STEM ACTIVATION

PROGRAM WEBSITE *- https://science.nasa.gov/learners*

SHORT DESCRIPTION

Since 2013, SMD has undergone a significant restructuring of science education-related activities. SMD no longer supports mission-by-mission education efforts but has aggregated towards meeting the needs of learners by offering science concept-based content consistent with how science is offered in the Nation's learning environments. SMD's vision for science education-related activities is:

To share the story, the science, and the adventure of NASA's scientific explorations of our home planet, the solar system, and the universe beyond, through stimulating and informative activities and experiences created by experts, delivered effectively and efficiently to learners of many backgrounds via proven conduits, thus providing a return on the public's investment in NASA's scientific research.

The desired outcome of the restructuring is to increase the overall coherence of our efforts leading to more effective, sustainable, and efficient utilization of SMD science discoveries and learning experiences and to meet overall SMD science education objectives. Fundamental to achieving this outcome is to enable NASA scientists and engineers to engage more effectively and efficiently in the learning environment with learners of all ages. Last September, SMD announced the selection of 27 institutions to receive cooperative agreements for up to ten years.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Dissemination of content through cooperative agreement awardees to meet desired outcome.
- 2017 Total Solar Eclipse learning objectives.
- Bi-annual Learner survey to track metrics.
- Annual external evaluation.

PARTNER OVERVIEW

- **NASA Center(s):** ARC, GSFC, JSC, LaRC, MSFC, JPL - FFRDC,
- **Federal Agencies:** USGS
- **International:** N/A
- **Academia:** Numerous
  THE FULL LISTING CAN BE FOUND AT *- http://www.nasa.gov/press-release/nasa-selects-science-education-partners-for-stem-agreements*
- **Industry:** N/A

APPROACH TO MISSIONS

The Space Technology research and development portfolio supports the entire range of technology maturation levels including early stage conceptual studies that focus on discovering new concepts and technologies, rapid competitive development and ground-based testing to determine feasibility, and flight demonstrations in relevant environments. This includes technologies that advance the U.S. space industry, other government agencies, NASA's future science missions, and human spaceflight endeavors beyond low-Earth orbit. To advance these critical technologies, NASA sources technology from the entire pool of potential technology suppliers: industry, academia, small businesses, other government agencies, individual entrepreneurs, and NASA centers. In addition, Space Technology utilizes public – private partnerships to leverage NASA resources, facilities and expertise to spur innovation and increase collaboration with the U.S. aerospace industry. These technologies progress through the technology pipeline supported by the portfolios and programs described below: Early Stage Portfolio, Commercial Partnerships Portfolio, Small Spacecraft Technology, Game Changing Development and Technology Demonstration Missions.

The Agency looks to Space Technology to enable future missions. To that end, Space Technology targets investments in technology thrust areas, key to future NASA missions and enhance national space capabilities. These enabling technology thrusts are space power and propulsion; life support and resource utilization; entry, descent, and landing; autonomy and space robotic systems; high bandwidth communications, deep-space navigation, and avionics; lightweight structures and manufacturing; and space observatory systems. Significant advances are required in these areas to enable more capable, affordable and reliable science and human exploration missions. By engaging the brightest minds on the toughest technological challenges, NASA spurs innovation throughout the aerospace enterprise.

In 2017, Space Technology will conduct a number of in-space demonstrations of technology including an integrated Green Propellant propulsion system, to demonstrate a higher performing, safe alternative to highly toxic hydrazine and a Deep Space Atomic Clock to improve navigational accuracy for deep space and improve gravity science measurements. In addition, three small spacecraft missions will launch in first quarter of FY 2017 demonstrating laser communications, formation flight, autonomous rendezvous, and docking in orbit, as well as radio frequency communications.

HIGHLIGHTS OF KEY ACHIEVEMENTS FOR FY 2016

- Manufactured and tested Solar Electric Propulsion thrusters and power processing unit and finalized advanced solar array design. Once proven, high-powered **Solar Electric Propulsion** can efficiently propel NASA's future robotic science and human exploration missions beyond the Earth and into deep space.
- Completed **Green Propellant Infusion Mission** spacecraft integration and testing for 2017 launch to demonstrate non-toxic propellant propulsion with the goal to provide an alternative to highly corrosive and highly toxic hydrazine propellant.
- Demonstrated ground modem optical communications for **Laser Communication Relay Demonstration** with MIT Lincoln Labs, and delivered an engineering model of the space switching unit to MIT Lincoln Labs. This project aims to prove optical communications technology in a near-Earth operational setting, providing data rates up to 100-times faster than today's radio frequency based communication systems.
- Delivered **Deep Space Optical Communications** photon counting camera to enhance NASA's deep-space telecommunications by 10 times without increasing mass, power, volume and/or spectrum use.
- Delivered a wax-based **Phase Change Material Heat Exchanger** to the International Space Station, to assess the performance of phase change heat exchangers in a micro-gravity environment for potential use on Orion.
- Delivered 16 small satellites through the **Small Spacecraft Technology** program and successfully completed two in-space demonstration missions and one suborbital flight.
- Awarded nearly one million dollars in prize funding in FY 2016 through the **Centennial Challenges Program**, including $750,000 to West Virginia University for developing a robot that located and retrieved samples without human control or use of terrestrial navigation aids.

TECHNOLOGY DEMONSTRATION MISSIONS

PROGRAM WEBSITE *- https://www.nasa.gov/mission_pages/tdm/main/*

SHORT DESCRIPTION

Space Technology conducts Technology Demonstration Missions to bridge the gap between early developments and mission infusion by demonstrating technology in a relevant operational environment. Ground-based and atmospheric demonstrations are used to mature new technologies to the point of a high-fidelity prototype. This program validates these prototypes in space to prove mission readiness. The current portfolio includes:

- **Green Propellant Infusion Mission:** Spaceflight demonstration of high-performance "green" propellant-based propulsion systems. The GPIM propulsion system utilizes AFM-315E, a non-toxic replacement for hydrazine that delivers a 40% improvement in volumetric impulse while reducing spacecraft propellant system processing and fueling costs by at least 50%.
- **Deep Space Atomic Clock:** Spaceflight of hosted demo of a small, low-mass atomic clock with unprecedented navigation accuracy in an on-board system for deep space navigation and timing, only drifting one second every 10,000,000 years.
- **Restore-L:** In Space demonstration of robotic satellite servicing including rendezvous with, inspecting and performing autonomous capture of client satellite to refuel, relocate, release, and safely depart from client satellite enabling on-orbit satellite life extension.
- **Solar Electric Propulsion:** Spaceflight demonstration of a 50 kW-class solar electric propulsion system, advancing electric thruster, power processor, and solar array technologies critical to the Asteroid Redirect Mission and ultimately the transportation system for human exploration to Mars. These technologies also have high interest from the commercial spacecraft market. The thrusters will operate at ~2.5 times the power level of the highest powered electric thrusters now in use. The advanced solar arrays are 2 times lighter and use 4 times less stowed volume for the amount of electricity produced than commercially available arrays, and can withstand 4 times more radiation exposure.
- **Laser Communications Relay Demonstration**: Two-year flight demonstration to advance optical communication technology for infusion into near-Earth operational systems. The outcome of this demonstration will benefit both commercial and government users by validating utility of optical communications technology in an operational setting, providing data rates up to 100-times faster than today's radio frequency-based communication systems.
- **Mars 2020 Technologies:** Mars Oxygen ISRU Experiment (MOXIE): Demonstrate small-scale *in situ* resource utilization technologies to enable oxygen production from the Martian atmosphere for propellant and human consumption on future exploration missions. Terrain Relative Navigation: Demonstrate on-board map relative position estimation and hazard avoidance during entry descent and landing operations. Both planned for development and demonstration in flight on SMD's Mars 2020 mission.
- **In-space Robotic Manufacturing and Assembly:** Launch-shroud size, lift capacity, and launch loads/environments limit the size and capabilities of systems pre-assembled on the ground and deployed using a single launch. With Orbital ATK, Made in Space and Space Systems Loral, NASA will develop and demonstrate technologies required to assemble, aggregate, and manufacture large and/or complex systems in space utilizing robotics technology. This disruptive capability could transform the traditional spacecraft-manufacturing model by enabling in-space creation of large spacecraft systems.
- **Deep Space Optical Communication:** Spaceflight demonstration of improved high-rate optical downlink from deep-space resulting in order-of-magnitude improved data-rate performance to state-of-art telecommunications systems. These technologies are considered essential for future human missions to Mars and have a wide range of applicable planetary science missions including those to Mars and Jovian systems.

PROGRAMS

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Launch and conduct demonstration mission of Green Propellant Infusion Mission and Deep Space Atomic Clock (FY 2017).
- Conduct critical design review, and deliver flight modems and Space Switching Unit as well as launch aboard STP-3 for space demonstration of laser communications.
- Develop and deliver electric propulsion system hardware in FY 2019 delivery for demonstration on Asteroid Redirect Robotic Mission.
- Develop and deliver MOXIE and TRN hardware to support Mars 2020.
- Develop Restore-L mission hardware and integrate, test and launch.

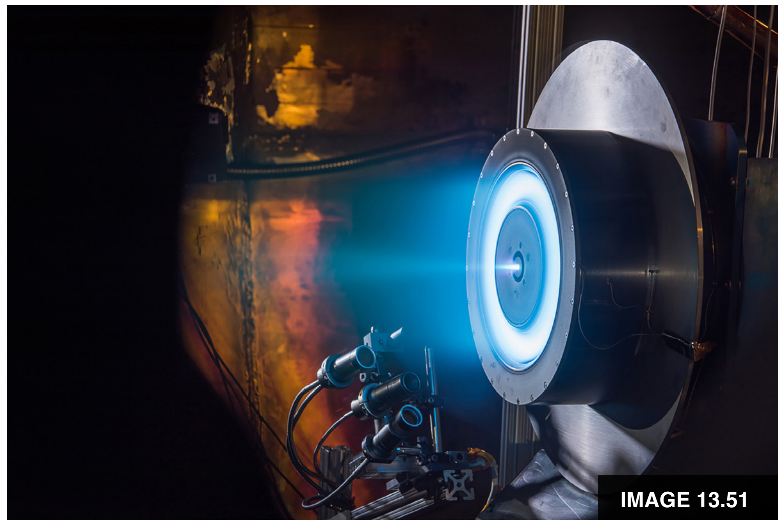


IMAGE 13.51

PARTNER OVERVIEW

- **NASA Centers:** Marshall Space Flight Center, Goddard Space Flight Center, Jet Propulsion Laboratory (JPL) – Federally Funded Research and Development Center (FFRDC), Langley Research Center, Glenn Research Center, Kennedy Space Center, Ames Research Center, Johnson Space Center
- **Federal Agencies:** United States Air Force, Defense Advanced Research Projects Agency, United States Geological Survey
- **International:** French Space Agency (CNES)
- **Academia:** California Institute of Technology, University of Colorado, MIT; Ohio Aerospace Institute
- **Industry:** Approximately 20 companies including Ball Aerospace, Aerojet Rocketdyne, Space Systems Loral, Surrey, Moog Broad Reach, Made in Space; ILC-Dover; Boeing; Lockheed-Martin, Northrop Grumman, Sierra Lobo Inc.; Orbital ATK; Deployable Space Systems

GAME CHANGING DEVELOPMENT

PROGRAM WEBSITE - http://www.nasa.gov/directorates/spacetech/game_changing_development/index.html

SHORT DESCRIPTION

Game Changing Development (GCD) aims to advance exploratory concepts and deliver infusion-ready technology solutions that enable new capabilities or radically alter current approaches. The program focuses on high-reward technologies and targets rapid maturation of technologies to be infused into NASA missions and advance commercial technologies and markets. Game Changing supports between 25-35 projects annually aligned with the Space Technology Thrust areas. Each project is given two to three years to advance technology with annual progress reviews. Current areas of emphasis include:

- **Entry, Descent and Landing:** Enable more capable future robotic and exploration missions to land on various bodies such as the Mars, moons, and asteroids. Robust and highly reliable solutions are essential to increase landed mass and enable precision landings. (Investments include: Entry Systems Modeling, Propulsive Descent Technologies, Thermal Protection Systems Materials)
- **Space Power and Propulsion:** Create improvements in power generation and energy storage for more capable science and human exploration missions, emphasizing thrust levels, specific power, and alternatives to traditional chemical propulsion systems for deep space exploration spacecraft systems. (Investments include: Advanced batteries, extreme environment solar power, nuclear thermal propulsion, and surface nuclear power systems)
- **Autonomy and Space Robotic Systems:** Enhance the efficacy of operations, and improve the ability to manipulate assets and resources through development of autonomous systems and advanced robotics. Through the use of remote and *in situ* sensors, machine learning and intelligent robotics, we are able to reduce human dependency, thereby expanding our reach in space. (Investments include: IBM Watson Collaboration, Crew Assistant Technology, Rover Technologies)
- **High Bandwidth Communications, Deep Space Navigation and Avionics:** Substantially increase the available bandwidth and data rates for near earth and deep space and assure data delivery through a robust interconnected space communications network. Within Navigation, increase capability for science and exploration missions to utilize advanced atomic clocks, x-ray detectors, and fast optical light gyroscopes for increased accuracy in deep space navigation. (Investments include: deep space navigation and High Performance Spaceflight Computing)
- **Advanced Life Support and Resource Utilization** Human exploration missions beyond low earth orbit requires highly reliable technologies that minimize resupply requirements and increase independence from earth. NASA is working toward closed loop life support systems, atmospheric capture and conversion for breathable air, recovery of water and volatiles from surface regolith on the Moon, Mars, and asteroids for production of water, oxygen, and propellant. (Investments include: Next Generation Life Support, Advanced Radiation Protection, Advanced Environmental Control and Life Support System)
- **Space Observatory Systems:** Enable advances in sensor and detector technologies to increase observation capabilities for greater science. (Investments include: Coronagraph Technology Development)
- **Lightweight Structures and Manufacturing:** Reduction of launch flight vehicle structural mass, as well as reduction in mass required for entry decent and landing and habitation systems by using innovative concepts and advanced manufacturing solutions to reduce cost and risk. (Investments include: Ultra Lightweight Deployable Boom, Near Net Shape Technologies, Bulk Metallic Glass, Automated Reconfigurable Mission Adaptive Digital Assembly Systems)

PROGRAMS

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2018

Accomplishments below are expected or planned within the FY 2017-FY 2018 timeframe. Game Changing Development makes fixed duration investments of 2-3 years with new or follow-on work prioritized based on technical progress and stakeholder needs.

- Deliver Station Explorer for X-ray Timing and Navigation Technology (SEXTANT) unit to integrate with the Neutron star Interior Composition Explorer (NICER) hardware for its mission on the International Space Station in FY2017. The goal of the NICER/SEXTANT mission will be to investigate pulsars and demonstrate real-time, autonomous spacecraft navigation using pulsars as beacons.
- Complete assessment study of 1kg of 90% purified Tungsten, and validate feasibility for a ground-based Nuclear Thermal Propulsion (NTP) demonstration.
- Award contracts for High Performance Spaceflight Computing development to bring greater processing power at significantly reduced power use over existing radiation-hardened processors.
- Deliver engineering hardware for Mars 2020 including: MEDLI-2 atmospheric entry sensors on the heat shield, Mars Environmental Dynamics Analyzer sensors that will provide measurements of temperature, wind speed and direction, pressure, relative humidity and dust on Mars.
- Complete flight verification on the International Space Station and complete on-orbit commissioning of Astrobee free flyer robots.
- Complete full-scale additive construction to demonstrate a mass construction material print head in partnership with Army Corps of Engineers.
- Deliver solar cell/solar array design concept technologies for space power applications in high radiation and for environments with limited concentrated sunlight.

PARTNER OVERVIEW

- **NASA Centers:** All
- **Federal Government:** National Science Foundation; U.S. Army Corps of Engineers; US Forestry Service; Department of Defense; Department of Energy
- **International:** Centro de Astrobiologia, Instituto Nacional de Tecnica Aeroespacial, Spain; Tel-Aviv University
- **Academia:** More than 50 Academic Institutions
- **Industry:** More than 85 companies

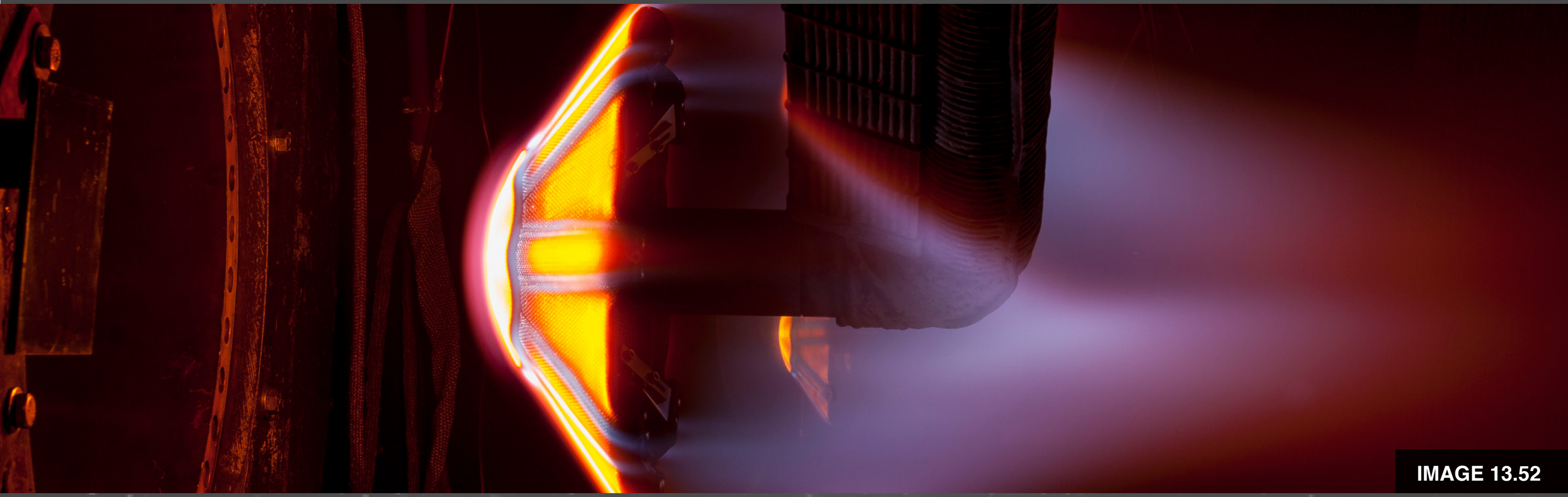


IMAGE 13.52

PROGRAMS

SMALL SPACECRAFT TECHNOLOGY

PROGRAM WEBSITE - *http://www.nasa.gov/directorates/spacetech/small_spacecraft/index.html#.VQb6QkjJzyE*

SHORT DESCRIPTION

Small Spacecraft Technology develops and demonstrates new capabilities employing the unique features of small spacecraft for NASA's missions in science, exploration, and space operations. Small Spacecraft are most often delivered to space using a rideshare approach, where the spacecraft uses launch vehicle capacity that would otherwise go unused by a primary payload. Collectively, the projects demonstrate technologies to enable NASA missions and commercial applications at much lower cost.

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2018

- Space Technology expects to have three small spacecraft missions launching in first quarter of FY 2017 to demonstrate: laser communications, formation flight and autonomous rendezvous and docking in orbit, and a radio frequency communication system that dramatically boosts the amount of data that a small satellite can transmit. An additional six new missions are planned for 2017-18.

PARTNER OVERVIEW

- **NASA Centers:** Ames Research Center, Goddard Space Flight Center, Marshall Space Flight Center, Glenn Research Center, Langley Research Center, Johnson Space Center, Jet Propulsion Laboratory (JPL) – Federally Funded Research and Development Center (FFRDC), Kennedy Space Center
- **Federal Agencies:** Air Force Research Laboratory
- **Academia:** Approximately 35 Academic Institutions
- **Industry:** Busek, Exoterra, Nexolve, Fibertek, Northrop Grumman Corporation,,Applied Defense Solutions; Tyvak Nano-Satellite System Inc., Blue Canyon Technologies, Aerojet Rocketdyne, Inc, Tethers Unlimited, Pumpkin, Inc.; The Aerospace Corporation

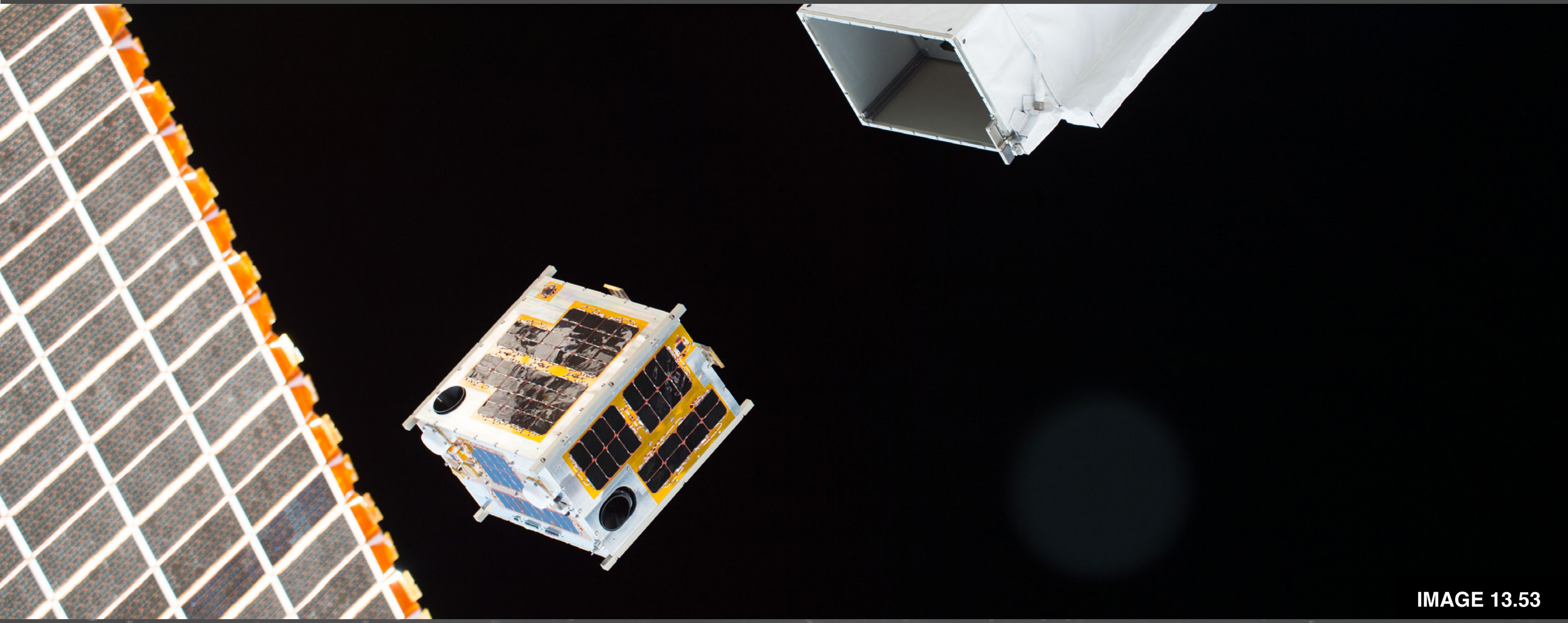


IMAGE 13.53

PROGRAMS

EARLY STAGE PORTFOLIO

SHORT DESCRIPTION

Space Technology invests in early stage space technology research and development sourced from academia, industry, entrepreneurs and from the NASA workforce to bring pioneering approaches to the Agency's difficult and far reaching challenges. While the National Research Council recommends 10%, the early stage portfolio currently represents roughly 8% of the STMD budget. NASA Centers are engaged in these efforts through the Center Innovation Fund and serve as collaborators to research grant recipients and NIAC awardees. STMD's early-stage portfolio maintained 333 activities in FY 2016, with nearly all focused within the Space Technology thrust areas. Within this portfolio are the following programs:

- **NASA Innovative Advanced Concepts:** Pushes the boundaries of what is currently possible, engaging visionary innovators to explore radical concepts and redefine the future of aerospace. NIAC issues both Phase I and continuation Phase II solicitations annually, open to NASA Centers, other government agencies, universities, industry, and individual entrepreneurs. In FY 2016, NIAC made 13 Phase I and 8 Phase II awards across industry, academia, and NASA Centers, while completing 15 2015 Phase I studies and 5 2014 Phase II studies. NIAC innovations have generated follow-on efforts by NASA and external stakeholders valued at more than $200 million dollars.
  WEBSITE - *http://www.nasa.gov/directorates/spacetech/niac/index.html#.VQb6I0jJzyE*
- **Space Technology Research Grants:** Challenges academia, from graduate students to senior faculty, to examine the theoretical feasibility of ideas and approaches that are critical to making science, space travel, and exploration more effective, affordable, and sustainable. Program issues awards annually for graduate student fellowships, and grants to Early Career Faculty and Early Stage Innovations. In FY16, Space Technology Research Grants awarded 58 fellowships, 15 Early Stage Innovations grants and 8 Early Career Faculty grants. Since inception, the program has funded research at 98 universities across 42 states with a total of 438 grants. Graduated fellowship recipients are now employed in industry, academia, and the government, including NASA Centers, and developed technologies have successfully transitioned to other projects, both internal and external to the Agency.
  WEBSITE - *http://www.nasa.gov/directorates/spacetech/strg/index.html#.VQb6T0jJzyE*
- **Center Innovation Fund:** Seeds technology to transform future missions by stimulating innovation at all NASA Centers. Annual awards are made to innovative proposals with credible potential to impact scientific, exploration, and aeronautical missions. Partnerships with academia, private industry, individual innovators, as well as other NASA Centers and Government agencies are encouraged.
  WEBSITE - *http://www.nasa.gov/directorates/spacetech/innovation_fund/index.html#.VQb6gUjJzyE*

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- STMD will select its first two Space Technology Research Institutes, as part of a new early stage initiative. Each institute will provide up to 5 years for university-led, sustained, multi-disciplinary space technology research focused in strategic areas for transformative impact to future NASA science and exploration. The first two STRI topics will be Bio-Manufacturing for Deep Space Exploration and Computationally Accelerated Materials Development for Ultra High Strength Lightweight Structures.

PARTNER OVERVIEW

- **NASA Centers:** ALL
- **Federal Agencies:** Department of Homeland Security; National Institute of Standards and Technology; Edgewood Chemical and Biological Center; National Center for Physical Acoustics; National Renewable Energy Lab, Sandia National Laboratories, Lawrence Livermore National Laboratory
- **International:** Finnish Meteorological Institute
- **Academia:** More than 85 academic institutions involved in FY16
- **Industry:** Approximately 15-20 in each year's portfolio

COMMERCIAL PARTNERSHIPS PORTFOLIO

SHORT DESCRIPTION

The Commercial Partnerships Portfolio engages both traditional and non-traditional partners in the established and emerging aerospace markets, small businesses, private citizens, and economic regions to leverage common interests and increase collaboration to address NASA needs and to grow an innovation economy. The portfolio includes Centennial Challenges, Flight Opportunities, Region Economic Development, and Small Business Innovative Research and Small Business Technology Transfer (SBIR/STTR).

- **SBIR/STTR:** Enables small businesses to deliver technological innovation that promotes economic growth for the benefit of NASA, industry, and society in accordance with the SBIR/STTR Reauthorization Act of 2011 (Public Law 112-81).
  WEBSITE - *http://www.nasa.gov/directorates/spacetech/sbir_sttr/index.html*
- **Flight Opportunities:** Advances the operational readiness of innovative space technologies while stimulating the development and utilization of the U.S. commercial spaceflight industry, particularly for the suborbital and small launch vehicle markets. Since its initiation in 2010, the program has provided affordable access to relevant space-like environments for over 100 payloads across a variety of flight platforms.
  WEBSITE - *http://www.nasa.gov/directorates/spacetech/flightopportunities*
- **Centennial Challenges:** Engages the public in the process of advanced technology development. The program offers incentive prizes to generate revolutionary solutions to problems of interest to NASA and the nation. The program seeks innovations from diverse and non-traditional sources. Competitors are not supported by government funding and awards are only made to successful teams when the challenges are met.
  WEBSITE - *http://www.nasa.gov/directorates/spacetech/centennial_challenges/index.html*
- **Regional Economic Development:** Accelerates innovation and commercialization through focused technology collaborations between NASA and multiple public, private, commercial, and economic development entities within strategic geographic regions of interest. For example, Space Technology is collaborating with the Black Chamber of Commerce in Detroit, to accelerate technology commercialization and strength the supply chains of interest to both NASA and the auto industry such as lightweight and high performance materials, fuel cells, and power storage.
  WEBSITE - *http://www.nasa.gov/directorates/spacetech/regional_economic_development*
- **Technology Transfer:** Shares the Agency's technology with industry, academia and other government agencies, making it simpler and faster for end users to access the benefits of the Nation's investment in aerospace research. New initiatives included Startup NASA, which provides favorable terms and assistance to new enterprises that form to commercialize NASA technology and the Gift to the Public Domain, which allocated several dozen patents for unencumbered public use. NASA also conducted a business plan competition designed to create startup companies, training them in entrepreneurship and then connecting them to venture capital.
  WEBSITE - *http://www.nasa.gov/offices/oct/techtransfer*

PROGRAMS

HIGHLIGHTS OF KEY ACHIEVEMENTS PLANNED FOR FY 2017 – FY 2020

- Host the final ground tournament for the Cube Quest Centennial Challenge (total prize purse of $5.05M). The purpose of this challenge is to design, build, and launch flight-qualified, small satellites capable of advanced operations near and beyond the moon, and to demonstrate communications and propulsion technologies. The top three teams will have the opportunity to launch their satellites on NASA's Space Launch System.
- Execute phases 2 and 3 of the 3-D Printed Habitat Centennial Challenge to advance autonomous, additive construction technology to create sustainable housing on Earth and beyond. The total prize purse for this challenge is $2.54M.
- Develop the suborbital and small launch vehicle market in addition to maturing technologies for future space missions.

PARTNER OVERVIEW

- **NASA Centers:** Centennial Challenges-Marshall Spaceflight Center; Flight Opportunities-Armstrong Flight Research Center; SBIR/STTR-Ames Research Center; Regional Economic Development-Langley Research Center
- **Federal Agencies:** Argonne National Laboratory. Federal Communications Commission; Air Force Research Laboratory-Kirtland Air Force Base; Defense Advanced Research Projects Agency; Department of Commerce (Economic Development Agency, National Institute of Technology and Standards and NIST Manufacturing Extension Partnership
- Other Government: Spacecoast Economic Development Commission, States of Michigan and Virginia, Chambers of Commerce, The New Economy Initiative
- **International:** Universitat Politecnica de Catalunya; Advanced Technical Institute I.T.I.S "E. Fermi"
- **Academia:** More than 100 academic institutions
- **Industry:** Approximately 400 industry partners (predominately small businesses)

IMAGE 13.54

NASA HQ OFFICE PROFILES

AERONAUTICS RESEARCH MISSION DIRECTORATE (ARMD)

MISSION STATEMENT

The Aeronautics Research Mission Directorate (ARMD) conducts high-quality, cutting-edge research that generates innovative concepts, tools, and technologies to enable revolutionary advances in our nation's future aircraft, as well as in the airspace in which they will fly. ARMD programs will facilitate a safer, more environmentally friendly, and more efficient national air transportation system.

OFFICE WEBSITE - *http://www.aeronautics.nasa.gov*

IMAGE 15.1

AERONAUTICS RESEARCH MISSION DIRECTORATE CORE FUNCTIONS

AIRSPACE OPERATIONS AND SAFETY
Develop and explore new technologies that increase efficiency of the nation's air traffic management systems, reducing flight delays and fuel consumption.

ADVANCED AIR VEHICLES
Develop the tools, technologies, and concepts that enable new generations of civil aircraft that are safer and more energy efficient.

INTEGRATED AVIATION SYSTEMS
Conduct experimental flight research, such as X planes and major demonstrations of transformative innovation.

TRANSFORMATIVE AERONAUTICS CONCEPTS
Cultivate multi-disciplinary, revolutionary concepts to enable aviation transformation and harness convergence in aeronautics and non-aeronautics technologies to create new opportunities in aviation.

AERONAUTICS RESEARCH MISSION DIRECTORATE ORGANIZATION

ARMD is led by the Associate Administrator who has two Deputy Associate Administrators that report directly to him. The two Deputy Associate Administrators oversee the strategic management and the operational/administrative management of the Mission Directorate through the Portfolio Analysis and Management Office and the Integration and Management Office.

The Associate Administrator also directly oversees the four Program Offices within the Mission Directorate: the Airspace Operations and Safety Program Office, the Advanced Air Vehicles Program Office, the Integrated Aviation Systems Program Office, and the Transformative Aeronautics Concepts Program Office. The four Program Offices located within the Aeronautics Research Mission Directorate oversee the execution of the projects at four NASA research centers: Ames Research Center, Armstrong Flight Research Center, Glenn Research Center, and Langley Research Center. Mission Directorate organizational chart provides insight into the official roles and relationships within ARMD.

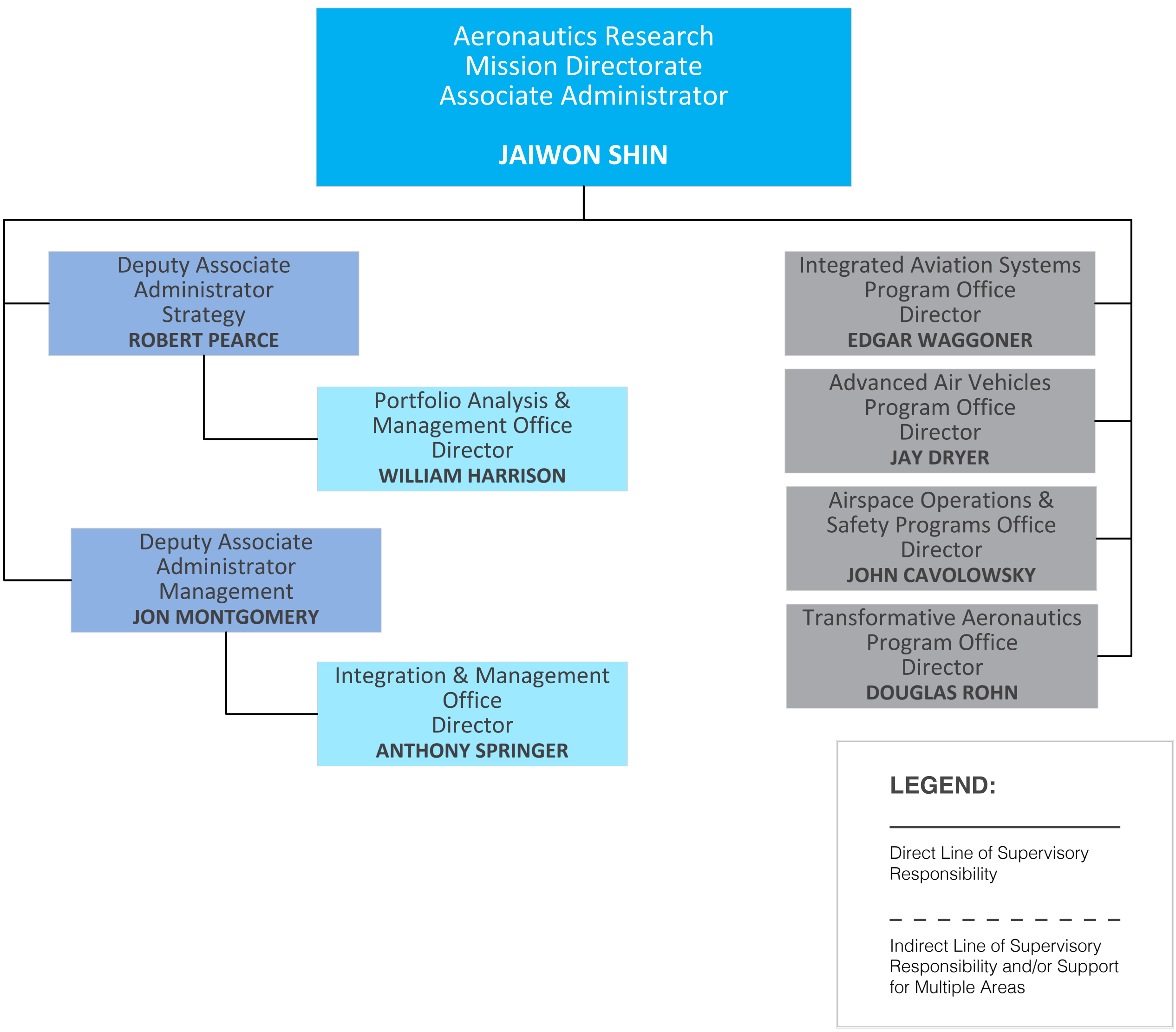


Figure 15.1 Aeronautics Research Mission Directorate (ARMD) Organization Chart

ASSOCIATE ADMINISTRATOR
DR. JAIWON SHIN

Dr. Jaiwon Shin is the Associate Administrator for the Aeronautics Research Mission Directorate (ARMD), a position he has held since 2008. Shin manages the Agency's aeronautics research portfolio and guides its strategic direction, including research in advanced air vehicle concepts, airspace operations and safety, integrated aviation systems, and the nurturing and development of transformative concepts for aviation.

Before becoming the Associate Administrator, he was the Deputy Associate Administrator for four years. Dr. Shin previously served as the Chief of the Aeronautics Projects Office at Glenn. Dr. Shin co-chairs the National Science & Technology Council's Aeronautics Science & Technology Subcommittee and is the current chair of the International Forum for Aviation Research.

EXTENDED BIO - *http://www.aeronautics.nasa.gov/people/shin_bio.htm*

DEPUTY ASSOCIATE ADMINISTRATOR FOR STRATEGY
MR. ROBERT A. PEARCE

Mr. Pearce is the Deputy Associate Administrator for Strategy and is responsible for strategic planning to guide the conduct of the Agency's aeronautics research and technology programs, as well as leading ARMD portfolio planning and assessments, mission directorate budget development and approval processes, and review and evaluation of all of NASA's aeronautics research mission programs for strategic progress and relevance.

Previously, he was the Director for Strategy, Architecture, and Analysis for ARMD. From 2003 until July 2010, Mr. Pearce was the Deputy Director of the FAA-led Next Generation Air Transportation System (NextGen), Joint Planning and Development Office (JPDO). Prior to JPDO Mr. Pearce held various strategic and program management positions within NASA.

EXTENDED BIO - *http://www.aeronautics.nasa.gov/people/pearce_bio.htm*

DEPUTY ASSOCIATE ADMINISTRATOR FOR MANAGEMENT
MR. JON N. MONTGOMERY

Mr. Montgomery is the Deputy Associate Administrator for Management. In this role he is responsible for leading the institutional responsibilities of the mission directorate, ensuring strategic business processes are in place to effectively plan and implement the ARMD mission, leading development and execution of ARMD strategies with respect to technical capabilities, partnerships, external communication, human resources, and managing the review and evaluation of programs for program planning and execution.

Previously he was the Director of the Integration and Management Office in ARMD. Prior to joining NASA in 2009, Mr. Montgomery was responsible for policies related to research and development, international trade, and global competitiveness of the U.S. aerospace industry at the U.S. Department of Commerce.

EXTENDED BIO - *http://www.aeronautics.nasa.gov/people/montgomery_bio.htm*

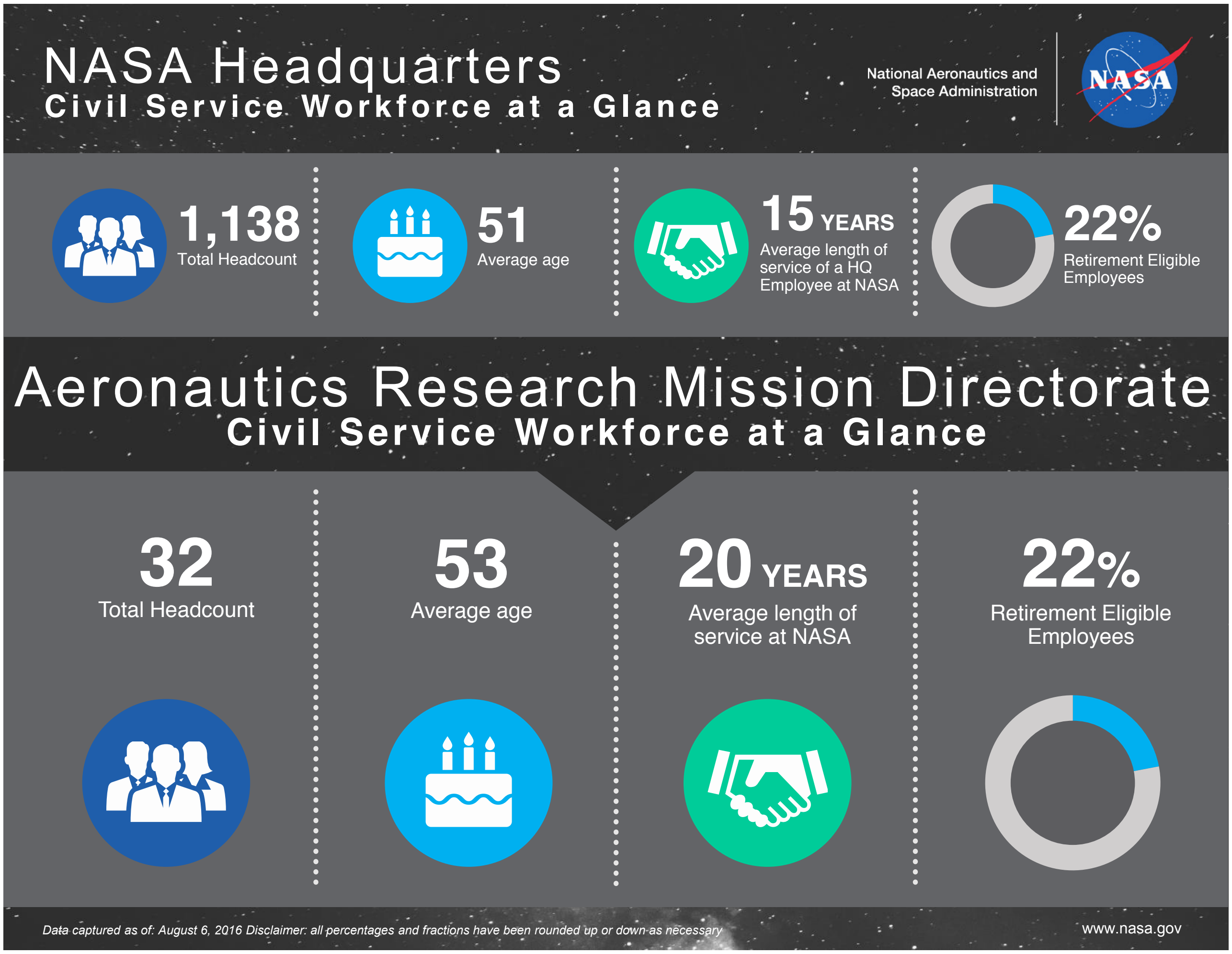


Figure 15.2 Aeronautics Research Mission Directorate Workforce at a Glance

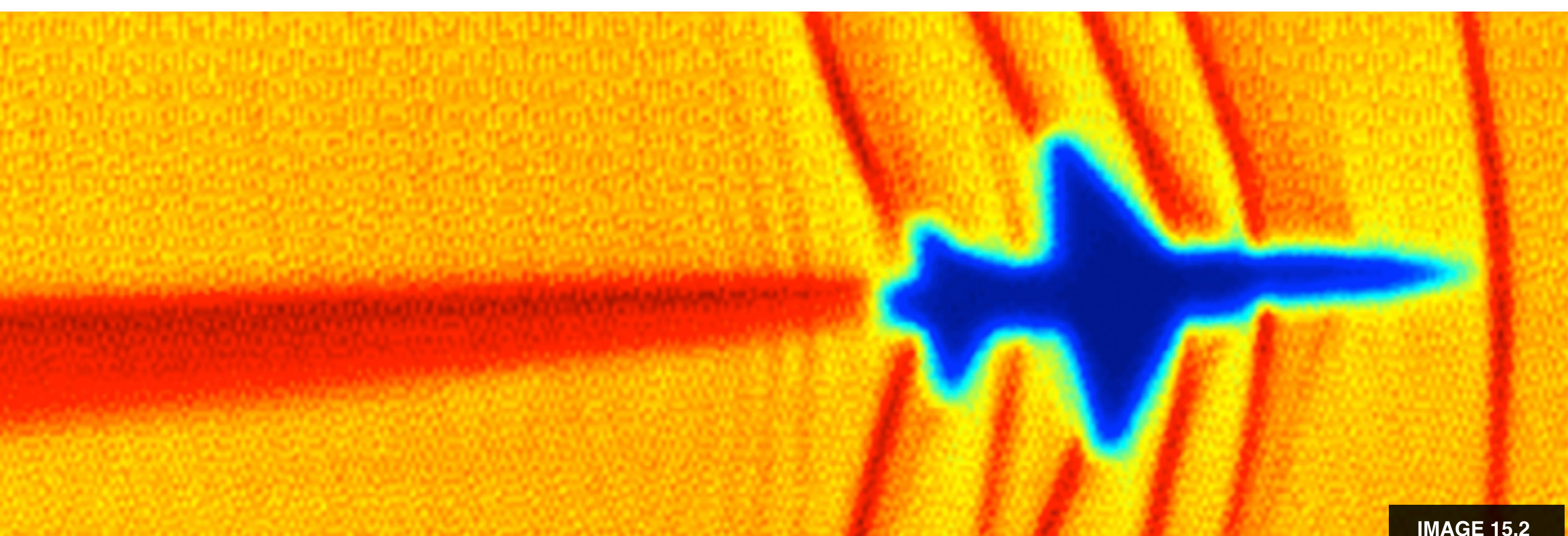


IMAGE 15.2

NEW AVIATION HORIZONS (NAH)

New Aviation Horizons (NAH) is the centerpiece of NASA's 10 year investment plan for advanced aircraft and propulsion research. It is an ambitious plan to build a series of five mostly large-scale experimental aircraft – X-planes – that will flight test new technologies, systems, and novel aircraft and engine configurations. Of the five X-planes, NASA has determined that three subsonic aircraft will be enough to span the range of possible configurations necessary to demonstrate in-flight the major enabling technologies to dramatically reduce aircraft fuel emissions and noise. Under NAH, NASA also will demonstrate quiet supersonic flight and more electric aircraft configurations. NAH builds upon a strong foundation of vehicle research to develop new aircraft and propulsion concepts and technologies.

THE AIRSPACE TECHNOLOGY DEMONSTRATIONS (ATD) PROJECT

The Airspace Technology Demonstrations (ATD) Project is comprised of a collection of critical technology development and demonstration activities to enable transformation of the nation's air traffic management system or NextGen. Research transition teams (RTT) are being used to coordinate and transition NASA technologies to the FAA for implementation. The Terminal Sequencing and Spacing – Flight Deck Interval Management activities, also referred to as ATD-1, will operationally demonstrate an integrated set of NASA arrival management software technologies for planning and executing efficient arrival operations in the terminal environment of a high-density airport. The Integrated Arrival/Departure/Surface activity, also referred to as ATD-2, will develop and adjust precision schedules for gates, spots, runways, and arrival and departure fixes while ensuring efficient individual aircraft trajectory.

CONVERGENT AERONAUTICS SOLUTIONS (CAS)

Convergent Aeronautics Solutions (CAS) consists of research (1 to 3 years) into early stage concept and technology feasibility studies to overcome key barriers facing the civil aviation industry. Internal teams propose ideas for overcoming key barriers associated with large-scale aeronautics problems. The focus is on making new capabilities in commercial aviation possible by merging traditional aeronautics disciplines with advancements driven by the non-aeronautics world. CAS teams conduct initial feasibility studies, perform experiments, try out new ideas, identify failures, and try again. At the end of that cycle, a review determines whether the developed solutions have met their goals, established initial feasibility, and identified real-world potential. During the reviews, the most promising capabilities will be considered for further development by other NASA aeronautics programs or by direct transfer to the aviation community.

IMAGE 15.3

THE AERONAUTICS EVALUATION AND TEST CAPABILITIES (AETC)

NASA maintains a number of unique assets critical to the lifecycle of real-world flight systems. The Aeronautics Evaluation and Test Capabilities (AETC) project manages NASA's versatile and comprehensive portfolio of ground test aeronautics research capabilities. It continues to make targeted investments in its capabilities so that the nation's aeronautics community (including NASA, other government agencies, and industry) has the tools such as wind tunnels and propulsion test facilities to deliver the technology innovations and breakthroughs necessary to address the increasingly complex research and development challenges associated with safe and effective real-world flight. AETC manages this capability portfolio on behalf of the Agency and provides Agency expertise to ensure safe and successful use of the assets and high quality of the research outcomes.

SAFE INTEGRATION OF UNMANNED AIRCRAFT SYSTEMS (UAS)

NASA is providing the world-leading research needed to safely integrate UAS into National Airspace System. NASA is working closely with the FAA, the FAA UAS Test Sites, and the overall UAS community to ensure collision avoidance, command and control, and other key safety functions are defined and flight validated. This work is executed, for both small, UAS flying at low altitude, and large, UAS flying at higher altitudes, to inform development of UAS-related standards and regulations. NASA research will ensure the economic benefits of this new market innovation are realized, without compromising safety.

ADDITIONAL RESOURCES

- Aeronautics Portal Topics Page
- Aeronautics Research Website
- ARMD Strategic Implementation Plan and Roadmaps
- NASA Aeronautics 10-Year Research Acceleration Plan Including the New Aviation Horizons Initiative
- NASA is With You When You Fly

HUMAN EXPLORATION AND OPERATIONS MISSION DIRECTORATE (HEOMD)

MISSION STATEMENT

Human Explorations and Operations Mission Directorate's (HEOMD) mission is to extend human presence into the solar system and to the surface of Mars. The NASA Authorization Act of 2010 and US National Space Policy of 2010 gave NASA goals to: 1) send humans to an asteroid by 2025; and 2) send humans to the vicinity of Mars by the mid-2030s. To prepare, HEOMD operates the International Space Station (ISS) as a test bed for long-duration exploration research and technology development. HEOMD partners with industry to acquire cargo and crew transportation services to ISS. HEOMD is now building NASA's new Space Launch System (SLS) and Orion crew exploration vehicle, which will enable many deep space missions. Throughout the 2020s, crewed missions of SLS and Orion will deploy and operate deep space habitation and propulsion systems that will validate our readiness to conduct human missions beyond the Earth-moon system in the 2030s. HEOMD invests in the new technologies and systems astronauts will need on the journey to Mars and provides and plans for current and future launch and space communication and navigation services to the Agency.

OFFICE WEBSITE - *https://www.nasa.gov/directorates/heo/index.html*

IMAGE 16.1

HUMAN EXPLORATION AND OPERATIONS MISSION DIRECTORATE CORE FUNCTIONS

INTERNATIONAL SPACE STATION (ISS)

Enabling research and technology developments that are benefitting human and robotic exploration of destinations beyond low Earth orbit (LEO) and the basis for developing a commercial market in LEO. ISS is the blueprint for global cooperation – one that enables a multinational partnership and advances shared goals in space exploration.

COMMERCIAL SPACEFLIGHT DEVELOPMENT (CSD)

Facilitating U.S. private industry development of safe, reliable, and cost-effective human space transportation to and from LEO and ISS for use by the U.S. Government and other customers.

EXPLORATION SYSTEMS DEVELOPMENT (ESD)

Building the Agency's foundational human exploration capabilities: the crew vehicle (Orion); next generation heavy lift launch vehicle (SLS); and advanced exploration ground systems to enable human exploration and operations to multiple deep space destinations extending beyond our Moon, to Mars, and across our solar system.

- Space Launch System (SLS): Transportation of astronauts in NASA's Orion spacecraft and other large exploration elements on missions beyond low Earth orbit. This system will have the ability to lift large masses off the Earth and will have more lift capability than any rocket in existence. This capability is needed for deep space missions.
- Orion Spacecraft: Serves as the exploration vehicle that will carry and sustain the crew during the space travel, providing emergency abort capability and safe re-entry from deep space.
- Exploration Ground Systems Development: Prepare the Kennedy Space Center to process and launch the next-generation launch vehicles and spacecraft designed to achieve NASA's goals for space exploration.

ASTEROID REDIRECT MISSION (ARM)

First use of capabilities needed to advance NASA's human journey to Mars which includes advanced solar electric propulsion, high speed autonomous rendezvous and proximity operations in a low gravity environment, 'touchdown' and 'liftoff' with a multi-ton mass, and support for crew operations for Asteroid sample selection, extraction, containment, and return to Earth.

SPACE LIFE AND PHYSICAL SCIENCES RESEARCH AND APPLICATIONS (SLPSRA)

Oversee basic and mission driven scientific research in support of human space flight, crew health and safety, and basic and applied scientific research in life and physical sciences.

ADVANCED EXPLORATION SYSTEMS (AES)

Pioneers new approaches for rapidly developing prototype systems, demonstrating key capabilities, and validating operational concepts for future human missions beyond Earth orbit into cis-lunar space, and eventually to Mars. AES activities are uniquely related to crew safety and mission operations in deep space, and are strongly coupled to future launch vehicle, habitation, and in-space transportation capability development. To make exploration systems more affordable and capable, AES incorporates advanced technologies developed in coordination with STMD, and uses innovative partnerships to engage industry, academia, and the public.

LAUNCH SERVICES PROGRAM (LSP)

Agency expertise for commercial space transportation, procuring commercial launch services for NASA's robotic spacecraft, certifying commercial launch vehicles, providing space transportation policy expertise, and conducting launch vehicle technical assessments and advisory support to the Cargo Resupply Services and Commercial Crew Programs.

SPACE COMMUNICATIONS AND NAVIGATION (SCAN)

Manage and Operate all of NASA's space communications and navigation capabilities required for successful crewed and robotic space missions and management of NASA's radio frequency spectrum.

HUMAN SPACEFLIGHT CAPABILITIES

Manage the functions of maintaining the health and safety of astronauts in training, during missions, and post flight recovery; oversee the quality of flight operations for crew members; and ensure availability of rocket test stands across the Agency.

HUMAN EXPLORATION AND OPERATIONS MISSION DIRECTORATE ORGANIZATION

The Associate Administrator, along with the Deputy Associate Administrator for Technical and Deputy Associate Administrator for Policy and Plans, oversee eleven divisions and offices chartered with developing and operating the core transportation elements, key systems, and enabling technologies required for beyond low Earth orbit human exploration that provides for continued American leadership in space exploration. These organizations include Exploration Systems Development, Human Spaceflight Capabilities, International Space Station, Commercial Spaceflight Development, Advanced Exploration Systems, and Space Life and Physical Sciences Research and Application Divisions. HEOMD also oversees the organizations that provide Agency-wide services and capabilities through the Space Communications and Navigation Program, Launch Services Office, and Rocket Propulsion Test Program. Budget formulation and execution and oversight of mission directorate business processes are provided by the Resources Management Office and Strategic Integration and Management Division. While work for HEOMD is performed at all ten NASA centers, the majority of work is concentrated at the four NASA human spaceflight centers: Kennedy Space Center, Johnson Space Center, Marshall Space Flight Center, and Stennis Space Center.

The organizational chart provides insight into the official roles and relationships within HEOMD.

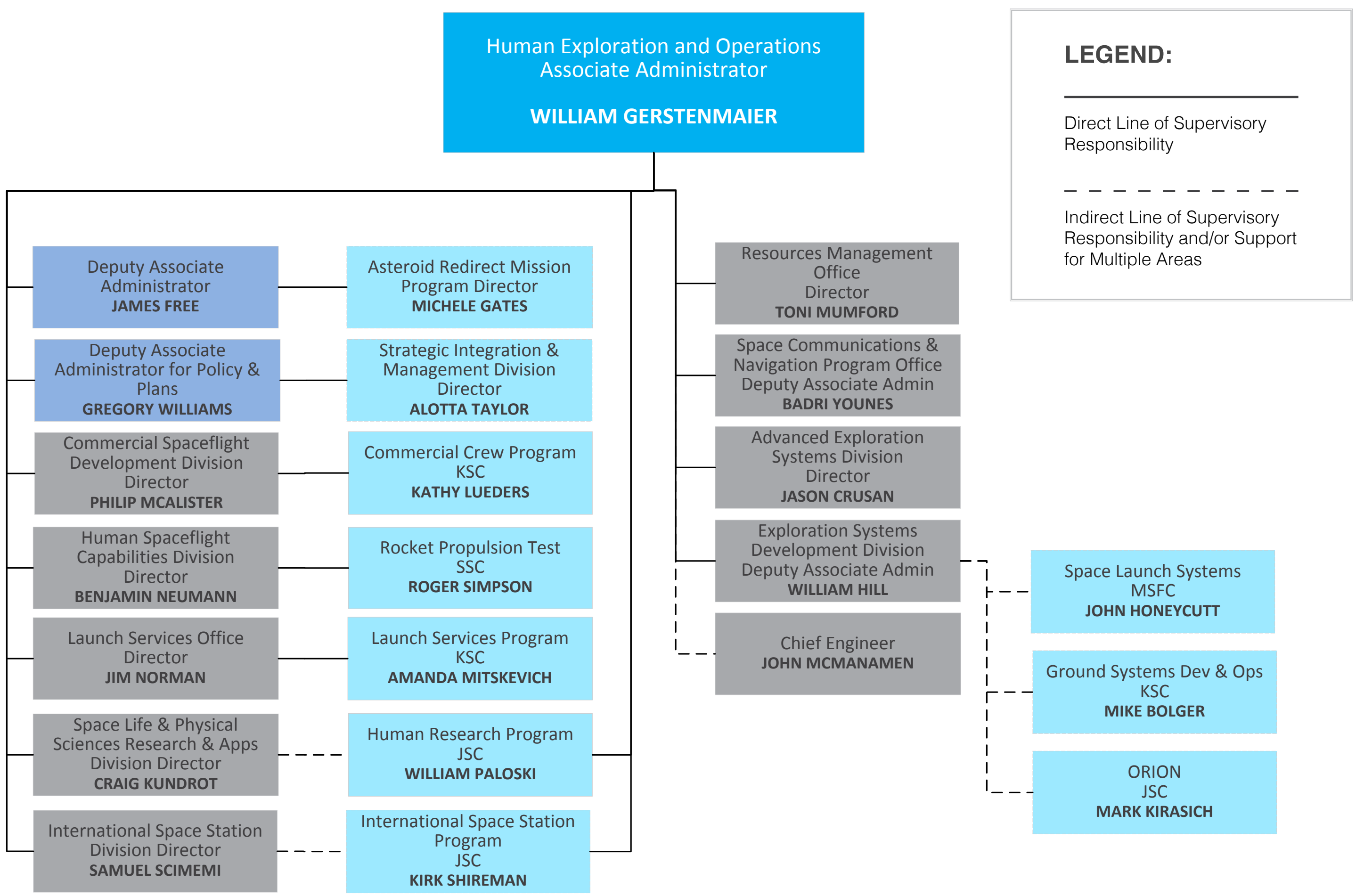


Figure 16.1 Human Exploration and Operations Mission Directorate (HEOMD) Organization Chart

ASSOCIATE ADMINISTRATOR

MR. WILLIAM (BILL) H. GERSTENMAIER

William H. Gerstenmaier is the Associate Administrator for the Human Exploration and Operations Mission Directorate at NASA Headquarters, in Washington, DC. He provides executive leadership and strategic direction for all aspects of the International Space Station (ISS), development of the Space Launch System and Orion spacecraft, Commercial Crew and Cargo programs that will provide logistics and crew transportation for ISS, as well as cross-Agency space support functions of space communications and space launch vehicles. His present duties include setting the strategic direction for the global human spaceflight endeavor. This is accomplished through Agency exploration forums and international leadership positions such as Chair of the ISS Multilateral Coordination Board.

EXTENDED BIO - *https://www.nasa.gov/about/highlights/gerstenmaier_bio.html*

DEPUTY ASSOCIATE ADMINISTRATOR FOR TECHNICAL

MR. JAMES (JIM) M. FREE

James Free is the technical Deputy Associate Administrator Human Exploration and Operations Mission Directorate at NASA Headquarters, in Washington, DC. In this role, he assists the Associate Administrator in providing executive leadership and strategic direction for all aspects of the International Space Station (ISS), development of the Space Launch System and Orion spacecraft, Commercial Crew and Cargo programs that will provide logistics and crew transportation for ISS, as well as cross-Agency space support functions of space communications and space launch vehicles. Mr. Free focuses on the technical aspects of strategic planning and development of systems within the Directorate. Prior to joining HEO, Mr. Free served as Director of the Glenn Research Center.

EXTENDED BIO - *https://www.nasa.gov/about/highlights/free_bio.html*

DEPUTY ASSOCIATE ADMINISTRATOR FOR POLICY AND PLANS

MR. GREGORY (GREG) J. WILLIAMS

Greg Williams is the Deputy Associate Administrator for Policy and Plans for Human Exploration and Operations Mission Directorate (HEOMD) at NASA Headquarters, in Washington, DC. In this role, he assists the Associate Administrator in charting the future course of NASA's human space exploration programs. He works to both shape and respond to the policy environment in which human spaceflight programs are conducted both internal and external to the Agency. Mr. Williams has overseen development of the journey to Mars planning for the Directorate. Prior to joining HEOMD, he was Deputy Director of the Strategic Integration and Management Division within NASA's Science Mission Directorate. He began his NASA career as a Presidential Management Intern in the Office of Space Station at NASA HQ.

EXTENDED BIO - *https://www.nasa.gov/about/highlights/williams_bio.html*

Figure 16.2 Human Exploration and Operations Mission Directorate Workforce at a Glance

IMAGE 16.2

EXPANSION OF KNOWLEDGE AND HUMAN ACTIVITY INTO THE SOLAR SYSTEM

NASA is extending robotic and human presence into the solar system through a strategy that advances the capability to operate at increasingly farther distances from Earth. Starting with Earth-reliant exploration, NASA is taking the first steps through ongoing research and technology development on the ISS, in partnership with private industry for cargo resupply, crew transport, and technology development. In parallel, NASA is preparing to transition to cis-lunar space through the development of the SLS, Orion, and supporting ground systems. This “Proving Ground” phase will include the robotic capture and transport of an asteroid to lunar orbit to be later explored by a crew aboard Orion. Experience in this phase will enable the Earth-independent phase of human exploration beyond the Earth-moon system which includes missions to the vicinity of Mars and eventually to the Martian surface. As a cross-Agency endeavor, the Science Mission Directorate has robotic spacecraft already on, around, and planned for Mars, increasing our knowledge and paving the way for human landings. The Space Technology Mission Directorate is developing solar electric propulsion, entry, descent and landing approaches, and other technologies and capabilities needed for human exploration.

LOW EARTH ORBIT (LEO) COMMERCIALIZATION

NASA’s objective is to transform management, development, operations, and research in low Earth orbit from a primarily government driven enterprise to a private industry driven commercial market with private supply and private and government demand. HEO is investing in developing and sustaining commercial transportation providers for cargo and crew in support of NASA’s ISS research and exploration missions. NASA is also making investments to develop private demand and non-NASA government demand, such as the National Institutes of Health, for LEO research via the National Lab. The goals and objectives of the National Lab are executed by the Center for the Advancement of Science in Space through a NASA Cooperative Agreement. NASA is also working with private industry and other government agencies, such as the Department of Commerce and the Federal Aviation Administration, to enable a suitable legal and regulatory environment to further enable and to sustain a viable commercial market in LEO.

BUSINESS SERVICES ASSESSMENT (BSA)

HEO recognizes the criticality of ensuring the Agency infrastructure is strategically sized and efficiently managed and is actively supporting NASA activities to establish a more efficient operating model that meets current and future mission needs. We cannot support an infrastructure designed for NASA’s missions from the 1970’s to the 1990’s for our missions that will take us into the 2020’s and beyond. As a key stakeholder, HEO personnel have been tapped to support a range of Business Services Assessments including Facilities, Budget, IT and Human Capital—serving as team members or subject matter experts. In addition, as decisions are made and implementation plans developed, HEO personnel are serving as members of the Implementation Teams or in a supporting role. Part of a larger effort, NASA and HEO are making a concerted effort to identify opportunities for optimization and develop risk-informed recommendations to live within our budget.

! ADDITIONAL RESOURCES

WWW Journey to Mars

SCIENCE MISSION DIRECTORATE (SMD)

MISSION STATEMENT

The Science Mission Directorate (SMD) carries out the scientific exploration of Earth and space to expand the frontiers of Earth science, heliophysics, planetary science, and astrophysics. Through a variety of robotic observatory and explorer craft and sponsored research, the directorate provides virtual human access to the farthest reaches of space and time and practical information about changes on our home planet.

OFFICE WEBSITE *- http://science.nasa.gov*

IMAGE 17.1

SCIENCE MISSION DIRECTORATE CORE FUNCTIONS

LEADING FUNDAMENTAL RESEARCH

Answering the Nation's most profound scientific questions put forth by the National Academies of Sciences, Engineering, and Medicine, SMD has over 100 spacecraft in operation or development, generating science data available to all. More than 10,000 US scientists in academia, industry, and government laboratories are funded by 3,000 grants to answer fundamental science questions of societal importance. SMD's extramural research program enables the US scientific community to continue to make major discoveries and helps preserve US leadership in science and engineering.

ENHANCING ENVIRONMENTAL STEWARDSHIP

SMD's advanced space missions make essential contributions to scientific assessments of the Earth, including climate change, that local governments, businesses, and citizens rely on to make significant investments and decisions. SMD develops and launches Earth science missions that provide scientific understanding of our complex planet through long-term global observations and provide the suite of measurements needed to advance US national interests (e.g., food and water security, air quality, disaster resilience, and response). SMD also works in partnership with 13 other federal agencies to determine the relative impact of human-induced and naturally occurring climate change, addressing an important scientific challenge and providing significant societal benefit.

DRIVING TECHNOLOGICAL INNOVATION

SMD's science missions explore the most extreme environments of Earth and space and as such are engines of innovation, leveraging technologies to solve scientific problems. These technologies enable the advanced space missions of the future, and yield applications in the broader economy in various fields such as manufacturing and health care that rely on imaging, data mining, and visualization technologies. SMD hosts over a dozen technology programs that advance instrument and platform technology beyond the current state of the art. Technology development for science missions is part of a comprehensive Agency-wide strategy that involves coordination with the NASA Chief Technologist and the Space Technology Mission Directorate (STMD). SMD's suborbital programs (comprising sounding rockets, balloons, and aircraft) and our cubesat initiatives, provide low-cost opportunities for innovative technology demonstration and complementary observations for our other science missions.

SCIENCE MISSION DIRECTORATE ORGANIZATION

SMD manages over 100 space missions in operation or development. Our four research divisions each have supporting research, technology, and data analysis programs to generate new scientific results and support missions. Suborbital programs, that are used by all four of our science divisions, complement space-based measurements, extend their scientific utility, test new technologies, and train young scientists and engineers. The four research divisions represent four major space-based research endeavors: Earth Science-advance Earth system science to meet the challenges of climate and environmental change. Planetary Science- ascertain the content, origin, and evolution of the solar system and the potential for life elsewhere. Heliophysics-understand the sun and its interactions with Earth and the solar system. Astrophysics-discover how the universe works, how it began and evolved, and search for exoplanets. SMD's science is highly interconnected; no important question stands alone. SMD is an organization where discoveries in one scientific discipline have a direct route to other areas of study. This level of interconnectivity is something extremely valuable and at the same time rare in the scientific world. The Joint Agency Satellite Division (JASD) manages our reimbursable programs, and the Resources Management Division (RMD) and the Strategic Integration & Management Divisions (SIMD) provide support in budget, administration, and policy matters.

The organizational chart provides insight into the official roles and relationships within SMD.

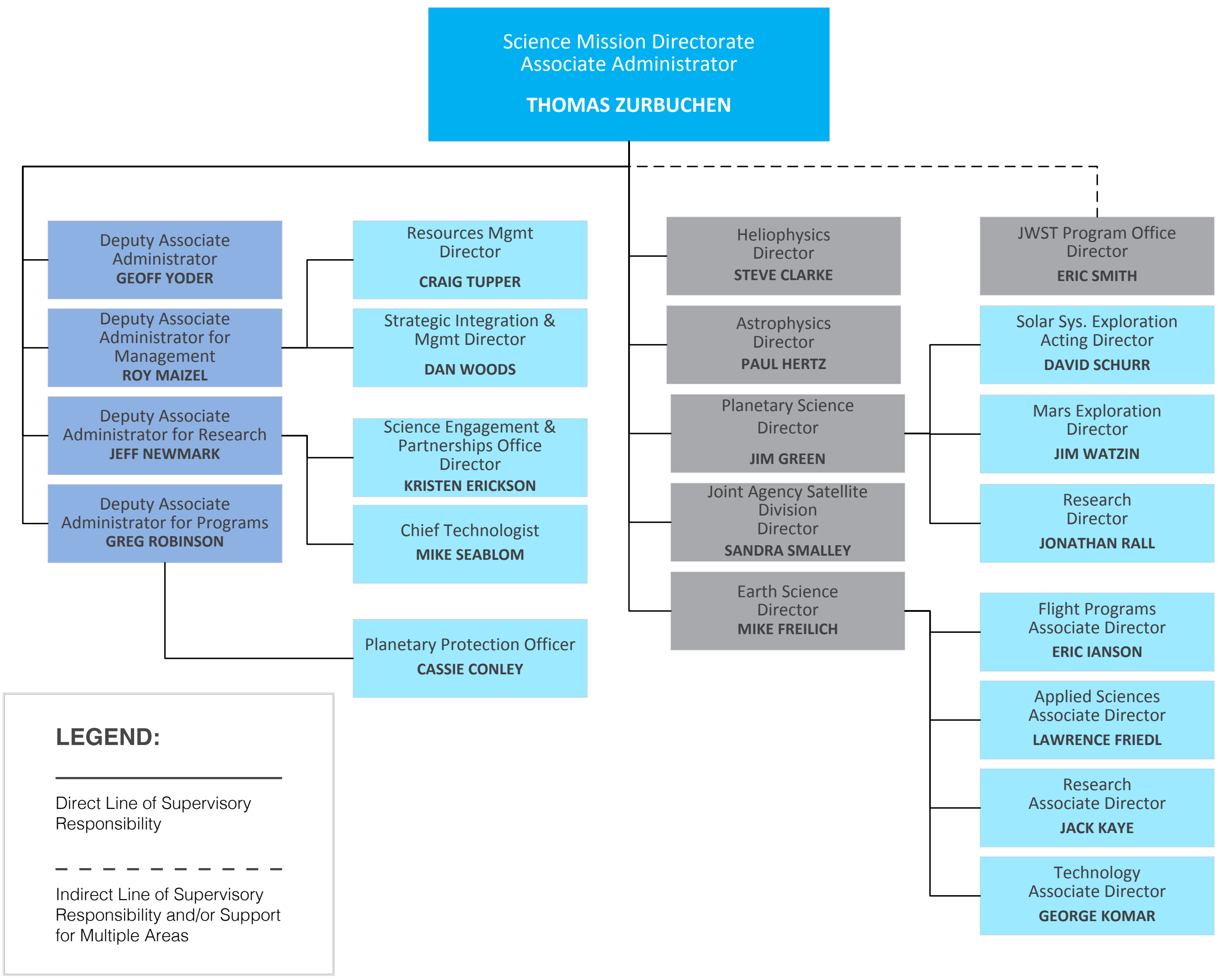


Figure 17.1 Science Mission Directorate (SMD) Organization Chart

ASSOCIATE ADMINISTRATOR
DR. THOMAS ZURBUCHEN

Dr. Thomas Zurbuchen is the SMD Associate Administrator; he joined NASA on October 3, 2016. Previously, he was a professor of Space Science and Aerospace Engineering at the University of Michigan (UM), the Associate Dean of Entrepreneurial Programs in the College of Engineering, a UM Senior Counselor for Entrepreneurial Education and the Founding Director of the UM Center for Entrepreneurship. Dr. Zurbuchen holds a Ph.D. in Astrophysics from the University of Bern, Switzerland, and has received numerous awards, including the prestigious U.S. Presidential Early Career Award. He also has a long record of service as a Chair and Member of committees advising NASA, NSF, and the DOL, and chaired or served on several committees of the National Academies.

EXTENDED BIO - *http://www.nasa.gov/press-release/thomas-zurbuchen-named-head-of-nasa-science-mission-directorate*

DEPUTY ASSOCIATE ADMINISTRATOR
MR. GEOFF YODER

Mr. Geoff Yoder is the SMD Deputy Associate Administrator. Previously, he was the SMD Associate Administrator (Acting), SMD Deputy Associate Administrator for Programs, Program Director for the James Webb Space Telescope, Director of the Office of Evaluation, and Deputy Director of the Astrophysics Division. Mr. Yoder joined NASA in 2000 in the Flight Hardware Development Branch at NASA/Johnson Space Center, and in 2005 he joined the Exploration Systems organization at NASA HQ serving in various roles, including Director of the Constellation Systems Division. From 1986 to 2000 he worked for Litton Systems on reliability assurance of various avionics suites and on various product improvement initiatives. He also served as Engineering Project Manager for various commercial, military, and space projects.

EXTENDED BIO - *https://science.nasa.gov/about-us/organization-and-leadership/office-of-the-associate-administrator/mr-geoffrey-l-yoder-deputy-associate/*

DEPUTY ASSOCIATE ADMINISTRATOR FOR PROGRAMS
MR. GREG ROBINSON

Mr. Greg Robinson is the Deputy Associate Administrator for Programs, responsible for technical and cost effectiveness, quality, and performance of SMD's 100+ projects. Mr. Robinson previously served as Deputy Center Director at NASA/Glenn Research Center, NASA Deputy Chief Engineer, and Acting Deputy Assistant Administrator for Systems in the National Oceanic and Atmospheric Administration (NOAA). He also spent 11 years at NASA/Goddard Space Flight Center. Mr. Robinson has received numerous awards, including the Presidential Rank, Distinguished Executive, and Meritorious Senior Professionals and Executives Award. He holds a B.S. in Math from Virginia Union University, a B.S. in Electrical Engineering from Howard University, and an MBA from Averett College. He also attended the JFK School of Government, Senior Executive Fellows Program, and the Federal Executive Institute.

EXTENDED BIO - *https://science.nasa.gov/about-us/organization-and-leadership/office-of-the-associate-administrator/mr-gregory-robinson-deputy-associate-administrator-programs*

DEPUTY ASSOCIATE ADMINISTRATOR FOR RESEARCH

DR. JEFF NEWMARK

Dr. Jeffrey Newmark was named the Deputy Associate Administrator for Research within NASA's Science Mission Directorate at NASA Headquarters in June 2016. He provides leadership and ensures the overall coordination of science programs. Dr. Newmark has over 25 years of experience, recently focusing on management and leadership pertaining to scientific, technical, and flight programs in Heliophysics. Dr. Newmark received his Ph.D. in Astronomy from the Pennsylvania State University in 1990 and worked at NASA's Goddard Space Flight Center until 2001. From 2001 until 2009, he worked at the US Naval Research Laboratory. From 2009 until 2016, Dr. Newmark worked in the Heliophysics Division at NASA Headquarters, including 1 year as Interim Division Director.

EXTENDED BIO *-https://science.nasa.gov/about-us/organization-and-leadership/office-of-the-associate-administrator/dr-jeffrey-newmark*

DEPUTY ASSOCIATE ADMINISTRATOR FOR MANAGEMENT

MR. ROY MAIZEL

Roy A. Maizel is the Science Mission Directorate's Deputy Associate Administrator for Management, a position he has held since 2008. He is responsible for the formulation and execution of the Directorate's budget, the guidance and oversight of all strategic planning and policy development activities, and the provision of administrative support to the Directorate's Headquarters organization. Mr. Maizel holds a B.A. in Political Science (1979) and an M.S. in Public Policy Analysis (1981) from the University of Rochester. Since joining NASA in 1981 as a Presidential Management Intern, Mr. Maizel has received numerous awards, including NASA's Exceptional Service Medal and the SES Meritorious Executive rank award.

EXTENDED BIO *- https://science.nasa.gov/about-us/organization-and-leadership/office-of-the-associate-administrator/dr-roy-maizel*

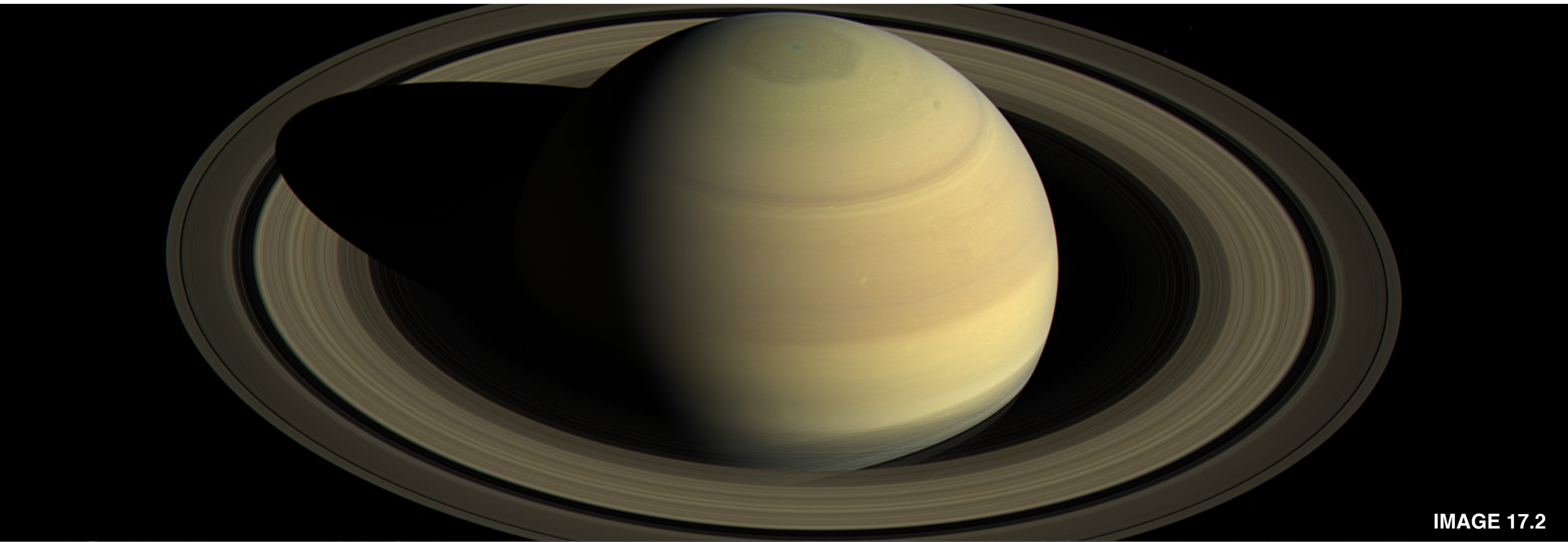


IMAGE 17.2

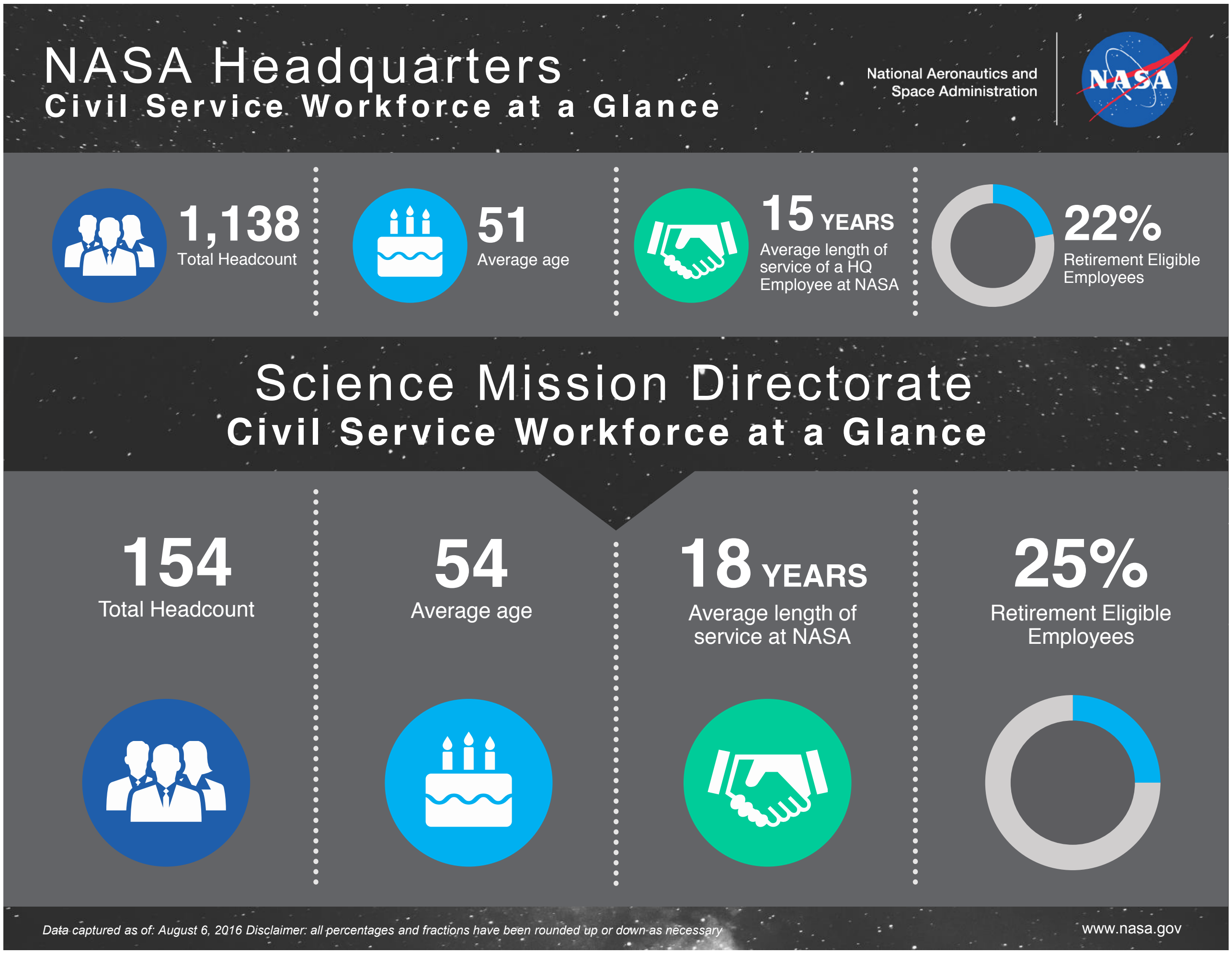


Figure 17.2 Science Mission Directorate Workforce at a Glance

IMAGE 17.3

NATIONAL SCIENCE PRIORITIES

NASA aligns its science programs with national policy and works towards implementing the priorities defined in the decadal surveys produced by the National Academies. The decadal surveys are the result of a science and mission prioritization process using broad scientific community input; they represent the broad consensus of the US scientific community and are the starting point for NASA's strategic planning process in the areas of Earth and space sciences. The Academies produce decadal surveys for each of SMD's four major science disciplines: Solar and Space Physics: A Science for a Technological Society (2013); Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond (2007); Vision and Voyages for Planetary Science in the Decade 2013–2022 (2011); and New Worlds, New Horizons in Astronomy and Astrophysics (2010). Based on national policy direction and recommendations from the nation's science community via these decadal surveys, each of the four SMD science divisions has developed plans for future missions and supporting research and technology. SMD turns the science priorities in these decadal surveys, and policy direction from the US Congress and the Administration, into an integrated program of innovation, discovery, exploration, and inspiration.

SEARCH FOR LIFE BEYOND EARTH

NASA is extending robotic and human presence into the solar system through a strategy that advances the capability to operate at increasingly farther distances from Earth. Working together, the Planetary Science and Astrophysics divisions are leading humankind on a voyage of unprecedented scope and ambition, addressing two of our most timeless questions: Where did we come from? and Are we alone? The study of Exoplanets, identified as a priority in the decadal surveys for Planetary Science and Astrophysics ("Vision and Voyages for Planetary Science in the Decade 2013-2022" and "New Worlds, New Horizons in Astronomy and Astrophysics"), helps us answer these questions. SMD's Astrophysics Division is searching for planetary systems around stars, determining the percentage of planets in the habitable zone of stars, and characterizing exoplanets for their habitability and other physical characteristics. While SMD's Planetary Science Division focuses on the origin and evolution of planets like Mars and moons like Europa, understanding the formation and evolution of planetary systems, and on how to characterize them. The two divisions cooperate on several exoplanet efforts, including using data from the Kepler mission (started in Planetary, now in Astrophysics) to confirm the existence of almost 4,000 exoplanets, which will be targets of study for future missions like the James Webb Space Telescope (JWST) and Wide Field Infrared Survey Telescope (WFIRST).

PROTECTING THE EARTH WHILE ADVANCING SCIENCE

SMD's scientific research not only advances our understanding of the Earth and space, but we help decision makers, first responders, and communities prepare for extreme weather, climate change, space weather events, and potentially hazardous near-Earth objects. SMD's programs use an interdisciplinary view of the Earth to explore the interaction among the atmosphere, oceans, ice sheets, land surface interior, and life itself. Space weather refers to variable conditions on the Sun and in the near-space environment that create risks for humans in space and can disrupt electrical power grids, communications, and navigation on the ground. Heliophysics research helps predict space weather events, mitigate their hazards, and understand their impacts throughout the solar system. Planetary science advances our understanding of planetary bodies and helps protect the Earth by identifying and characterizing celestial bodies that may pose threats to our planet.

IMAGE 17.4

INSPIRING THE NEXT GENERATION AND CREATING A WORLD-CLASS WORKFORCE

Stunning imagery and data from the Hubble Space Telescope, Solar Dynamics Observatory, and Cassini; the exploits of the Mars rovers; and the amazing discoveries of other space and Earth science missions spark imagination, enable STEM education, and encourage people to become scientifically knowledgeable citizens. The thousands of scientists funded by SMD are, in turn, training graduate students, teaching undergraduates, and providing research results for use in teacher-tested education tools. Engineers and scientists at NASA are training their junior peers and inventing new design tools for the workforce of the future. Our premier scientific laboratories, mission teams, and NASA-funded academic groups feed the broader US workforce. Together, we are building a technical US workforce that embodies the values of excellence, innovation, and service which will lead the world in future discoveries.

EXPANDING PARTNERSHIPS

Science is a broad international enterprise. SMD partners with over a dozen federal agencies, numerous academic institutions, and 60+ different nations to leverage ideas, capabilities, and resources. NASA and the National Science Foundation (NSF) advance our understanding of the universe, with NASA providing space-based- and NSF ground-based- observatories. NASA and the Department of Energy (DOE) jointly study the fundamental physics of the universe, and develop nuclear power sources for space missions. NASA partners with other nations to send spacecraft to asteroids, comets, and other planets. NASA develops models of space weather and collaborates with the National Oceanic and Atmospheric Administration (NOAA) and the Department of Defense (DOD), who use our models in operational forecasting systems. SMD's Joint Agency Satellite Division (JASD) manages the development and launch of weather satellites for NOAA on a reimbursable basis. The US Department of Agriculture (USDA), Federal Aviation Administration (FAA), Environmental Protection Agency (EPA), the US Geological Survey (USGS), and many others use NASA's Earth science data, while SMD collaborates with the NSF on research about Antarctica that spans all four SMD science disciplines. Working together we accomplish more than working alone.

! ADDITIONAL RESOURCES

- www SMD Leadership & Bios
- www SMD Science Plan
- www SMD Management Handbook
- www SMD Mission Handbook
- www SMD Education

SPACE TECHNOLOGY MISSION DIRECTORATE (STMD)

MISSION STATEMENT

Space Technology Mission Directorate (STMD) rapidly develops, demonstrates, and infuses revolutionary, high-payoff technologies, expanding the boundaries of the national aerospace enterprise. STMD employs a merit-based competition model with a portfolio approach spanning a range of discipline areas and technology readiness levels to advance technologies for the benefit of NASA, the aerospace industry, government Agencies, and national needs. STMD research and technology development takes place within NASA Centers, in academia and industry, other government agencies, and international partners via partnerships. Through STMD, NASA invests in broadly applicable, transformative technologies with high potential for reducing mission risk, reducing cost, and advancing capabilities; enabling new missions for NASA and new capabilities for the nation. STMD engages with and inspires technologists and innovators, creating a cadre of the best and brightest scientists and engineers working on the nation's toughest challenges.

OFFICE WEBSITE *- http://www.nasa.gov/directorates/spacetech/home/index.html*

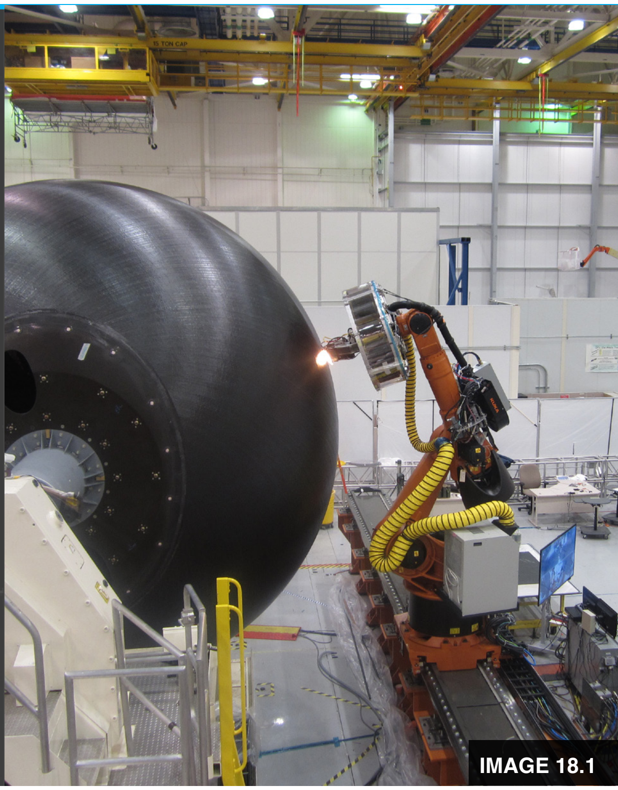


IMAGE 18.1

SPACE TECHNOLOGY MISSION DIRECTORATE CORE FUNCTIONS

GAME CHANGING DEVELOPMENT
Rapid advancement of disruptive space technologies from concept to demonstration; maturing transformational technologies across the critical gap between early stage research and flight demonstration.

TECHNOLOGY DEMONSTRATION MISSIONS
Demonstrate systems capabilities in relevant environments to support the maturity of system-level space technologies that can benefit multiple NASA missions, other government agencies, and aerospace industry stakeholders.

SMALL SPACECRAFT TECHNOLOGY
Develop and demonstrate new technologies and capabilities that employ the unique features of small spacecraft for NASA's missions in science, exploration, and space operations with an aim to promote small spacecraft missions as a paradigm shift for NASA and the larger space community.

EARLY STAGE PORTFOLIO
Research and Development sourced from academia, industry, entrepreneurs, and from the NASA workforce to bring pioneering approaches to the Agency's difficult and far-reaching exploration challenges. Activities in this portfolio include: NASA Innovative Advanced Concepts; Space Technology Research Grants; and the Center Innovation Fund.

COMMERCIAL PARTNERSHIPS PORTFOLIO

Engages the established and emerging aerospace markets, private citizens, and economic regions to leverage common interests, and increase collaboration by engaging a wide variety of stakeholders in NASA's mission. Activities in this portfolio include: Flight Opportunities; Centennial Challenges; Technology Transfer; and Regional Economic Development.

SMALL BUSINESS INNOVATION RESEARCH (SBIR) AND SMALL BUSINESS TECHNOLOGY TRANSFER (STTR) PROGRAMS

These programs provide an opportunity for small, high technology companies and research institutions to develop key technologies addressing the Agency's needs and developing the nation's innovation economy.

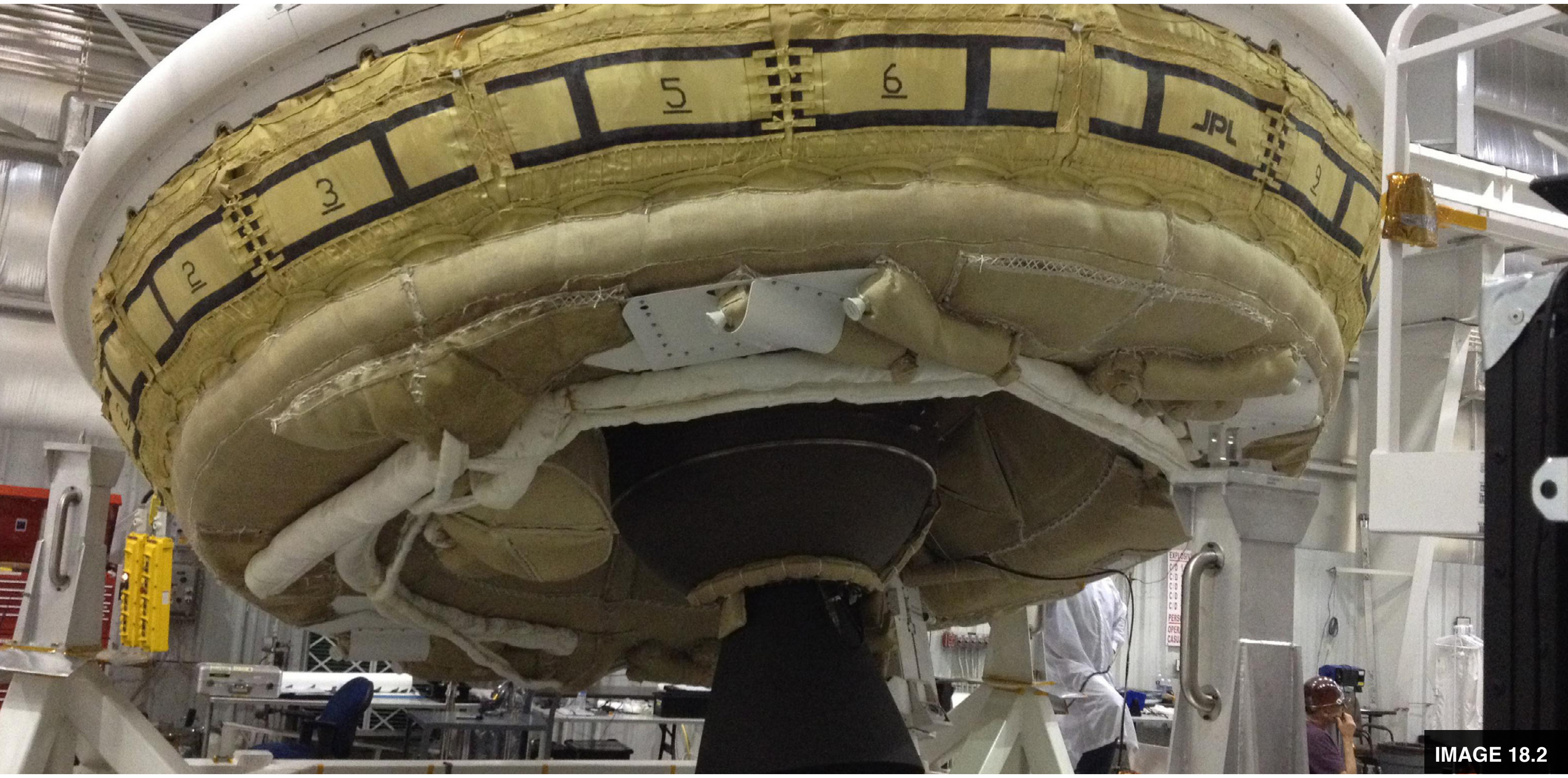


IMAGE 18.2

SPACE TECHNOLOGY MISSION DIRECTORATE ORGANIZATION

The Headquarters office of the Space Technology Mission Directorate (STMD) is responsible for managing the directorate's program portfolio and is accountable for mission safety and success for the programs and projects assigned to them. STMD is led by the Associate Administrator who has three Deputy Associate Administrators that report directly to him. The office maintains staff necessary to define, fund, evaluate, and oversee the implementation of STMD programs and projects to ensure their outcomes meet schedule and cost constraints. They establish and maintain the directorate's strategy to meet Agency goals, missions, top-level requirements, schedules, and budgets.

The organizational chart provides further insight into the official roles and relationships within STMD.

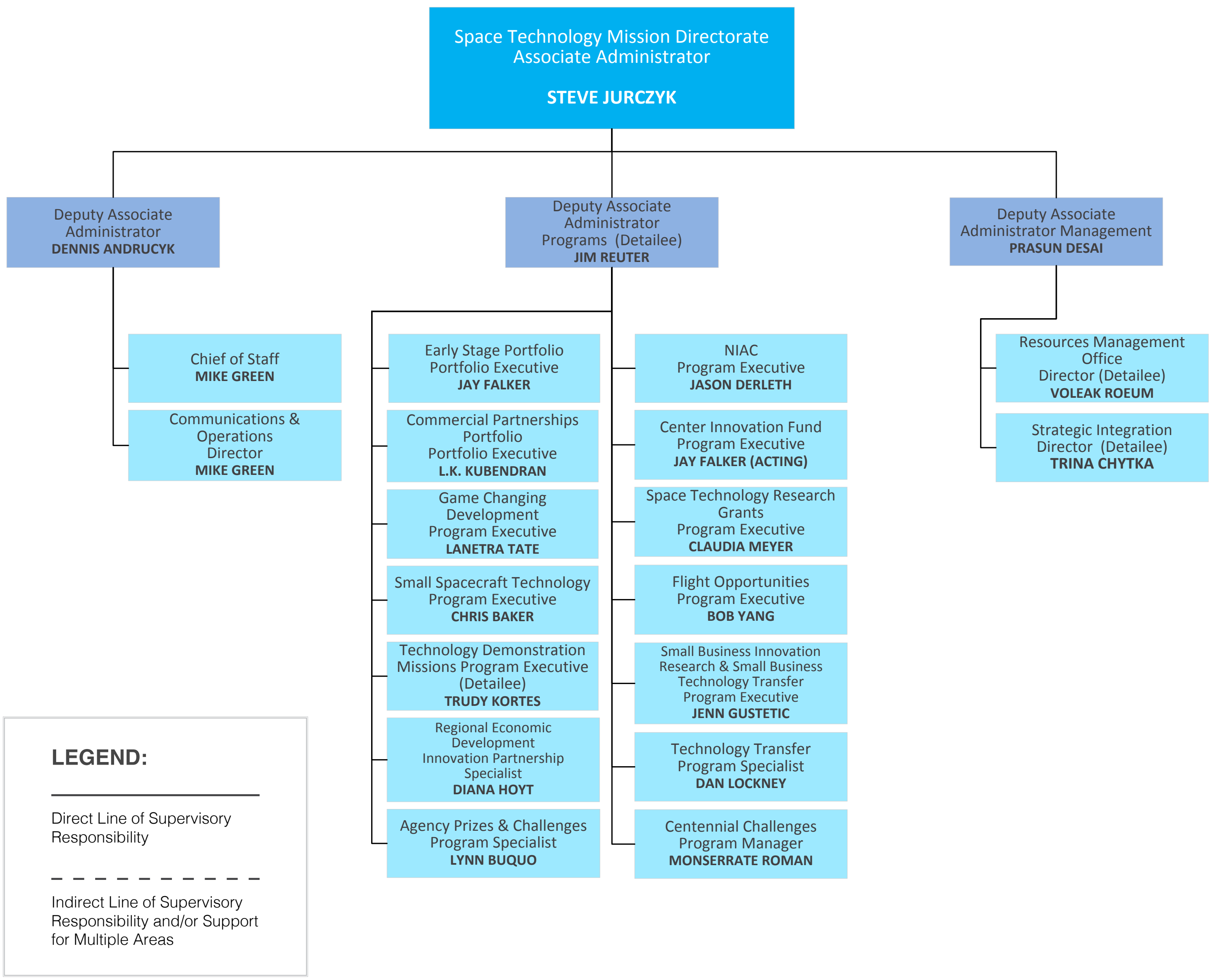


Figure 18.1 Space Technology Mission Directorate (STMD) Organization Chart

ASSOCIATE ADMINISTRATOR
MR. STEPHEN JURCZYK

Steve Jurczyk serves as Associate Administrator (AA) for Space Technology, which rapidly develops, demonstrates, and infuses revolutionary, high-payoff technologies expanding the boundaries of the aerospace enterprise. Prior to this appointment, he served as Center Director at Langley, responsible for technical implementation of aeronautical, space, and science programs. During his 28-year career with NASA, Jurczyk worked in systems engineering, research, and technology development, and management at Headquarters, Langley, and Goddard. He has received the NASA Outstanding Leadership Medal and the Presidential Rank Award of Meritorious Executive. Jurczyk received a B.S. and M.S. in Electrical Engineering from the University of Virginia.

EXTENDED BIO - *http://www.nasa.gov/directorates/spacetech/about_us/bios/jurczyk_bio.html*

DEPUTY ASSOCIATE ADMINISTRATOR
MR. DENNIS ANDRUCYK

Dennis Andrucyk serves as Deputy Associate Administrator for the Space Technology Mission Directorate. He works under the general direction of the STMD AA and shares the full range of responsibilities with special emphasis on general management of the organization. Andrucyk has held many leadership positions at NASA's Goddard Space Flight Center, including Chief Technologist and Director of the Applied Engineering and Technology Directorate. He has earned numerous awards, including the Senior Executive Service Meritorious Presidential Rank Award and NASA Medal for Outstanding Leadership. Before joining NASA in 1988, Andrucyk served at the Department of Defense, the National Security Agency, the Naval Research Laboratory, Westinghouse Electric, General Electric, and the Northrop Grumman Corporation. Andrucyk holds a B.S. in Electrical Engineering from the University of Maryland.

EXTENDED BIO - *http://www.nasa.gov/directorates/spacetech/about_us/bios/andrucyk_bio.html*

IMAGE 18.3

DEPUTY ASSOCIATE ADMINISTRATOR FOR PROGRAMS

MR. JAMES REUTER

Jim Reuter serves as the Deputy Associate Administrator for Programs for the Space Technology Mission Directorate. He provides management of the organization's technology programs, leads budget planning and allocation of resources, and ensures that investments align with the NASA Strategic Plan and roadmaps. Since joining NASA in 1983, Reuter served in a variety of managerial roles at NASA's Marshall Space Flight Center, including Deputy Space Shuttle Propulsion Manager, and Deputy Shuttle External Tank Project Manager during the STS-114 Return to Flight mission, as well as Senior Executive for Technical Integration. Reuter has also held leadership positions at Headquarters and Johnson Space Center, including managing the Environmental Control and Life Support System during International Space Station development. Reuter has received many awards from NASA, including four NASA Medals and a Silver Snoopy. He has a B.S. in Mechanical Engineering from the University of Minnesota.

EXTENDED BIO - *http://www.nasa.gov/directorates/spacetech/about_us/bios/reuter_bio/*

DEPUTY ASSOCIATE ADMINISTRATOR FOR MANAGEMENT

DR. PRASUN DESAI

Dr. Prasun Desai serves as Deputy Associate Administrator for Management for the Space Technology Mission Directorate. He oversees all aspects of operations, management and execution including personnel, budget, communications, strategic planning, and integration. In his 26-year career at NASA, Desai has worked at Headquarters establishing STMD, and as a systems engineer at Langley in the areas of atmospheric flight dynamics, systems optimization, engineering of entry systems, and design of mission elements for robotic and human systems. He has received many awards, including four NASA medals such as NASA's Exceptional Service Medal and the National Engineer of the Year Award from the AIAA. Desai has a B.S. in Mechanical Engineering from Rutgers University, an M.S. in Astronautics from the George Washington University, and a Ph.D. in Aerospace Engineering from the University of Illinois.

EXTENDED BIO - *http://www.nasa.gov/directorates/spacetech/about_us/bios/desai_bio.html*

IMAGE 18.4

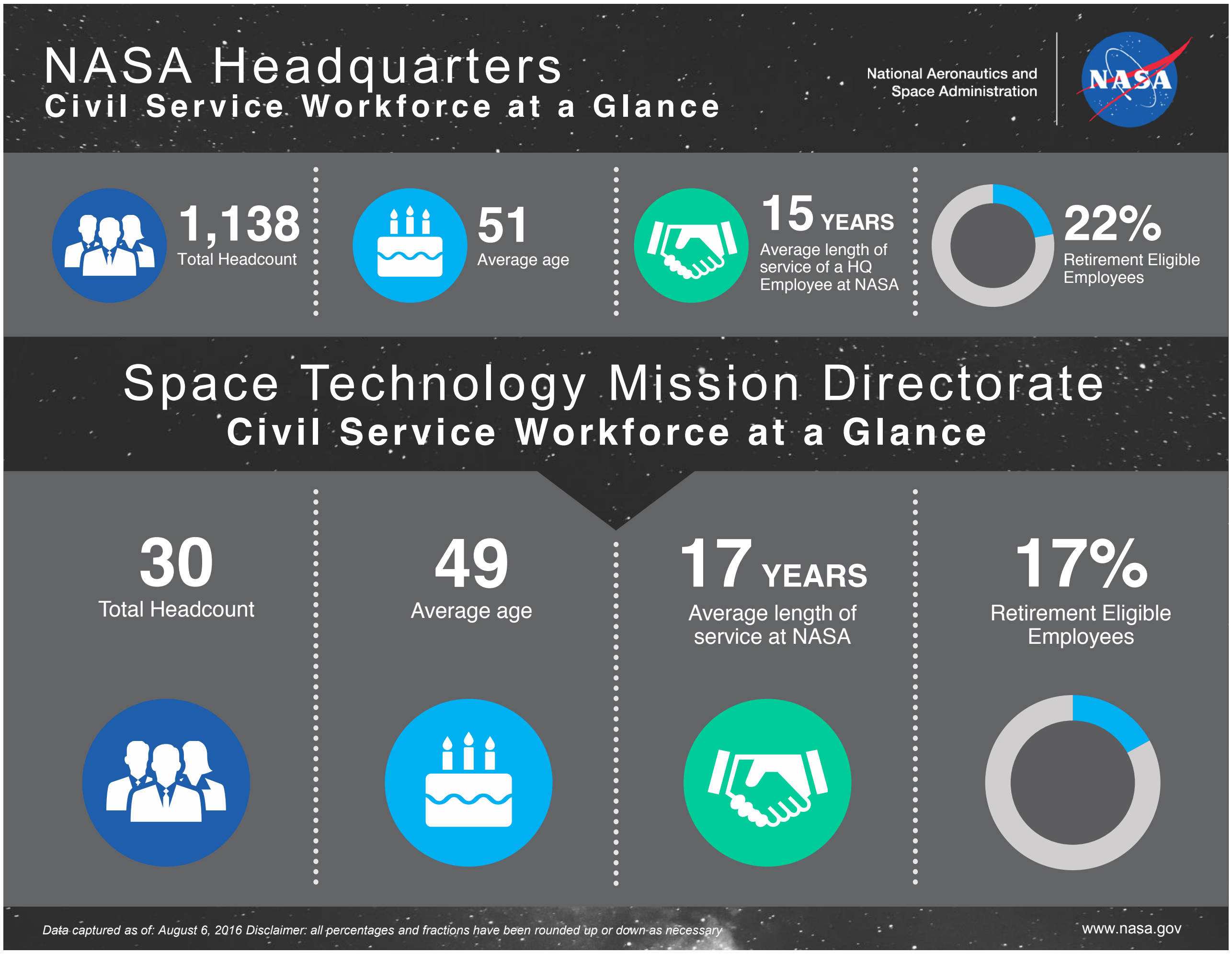


Figure 18.2 Space Technology Mission Directorate Workforce at a Glance

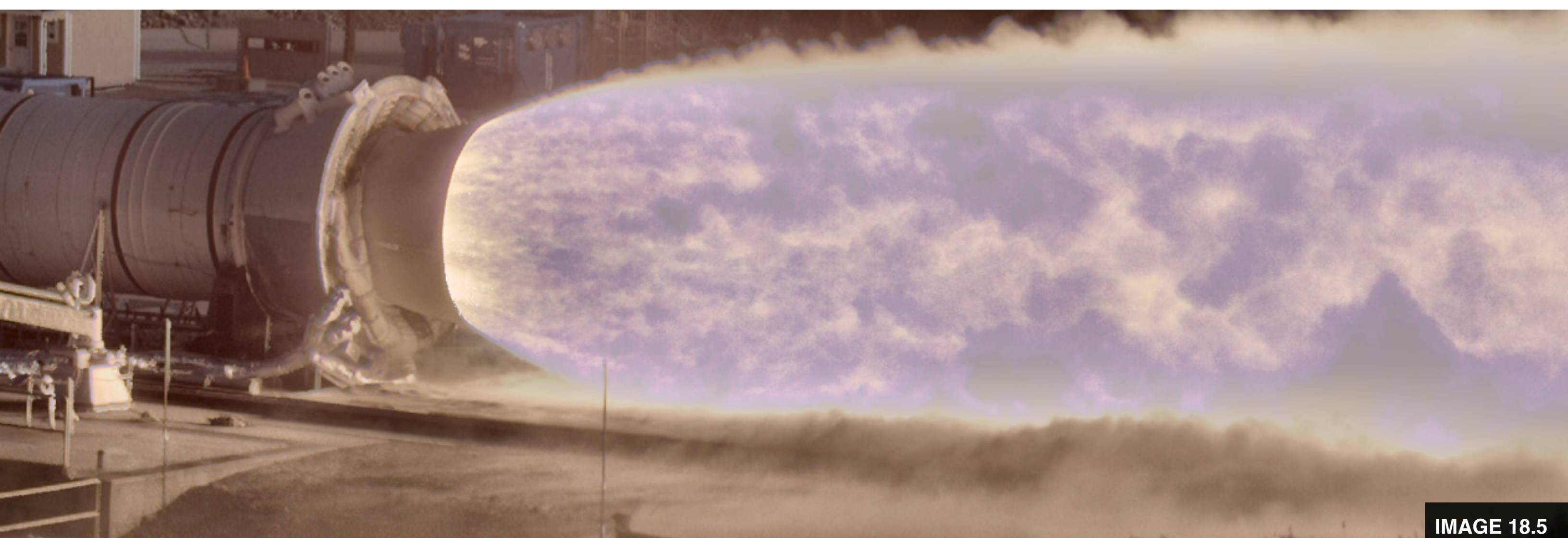


IMAGE 18.5

EXPANSION OF KNOWLEDGE AND HUMAN ACTIVITY INTO THE SOLAR SYSTEM

NASA is extending robotic and human presence into the solar system through a strategy that advances the capability to operate at increasingly farther distances from Earth. The powerful new Space Launch System rocket and the Orion spacecraft will travel into deep space, building on our decades of robotic Mars exploration, lessons learned on the International Space Station, and groundbreaking new technologies. STMD engineers and technologists around the country are working hard to develop technologies including Solar Electric Propulsion, Deep Space Optical Communications, and Entry, Descent, and Landing systems. STMD is developing and testing technologies that would harvest resources from the Mars atmosphere and surface, and develop more reliable and self-sustaining life support systems to enable astronauts to travel, land, and work on Mars.

NATIONAL NETWORK FOR MANUFACTURING INNOVATION (NNMI)

The National Network for Manufacturing Innovation (NNMI) consists of linked Institutes for Manufacturing Innovation (IMIs) with common goals, but unique concentrations. Here industry, academia, and government partners are leveraging existing resources, collaborating, and co-investing to nurture manufacturing innovation and accelerate commercialization. Space Technology supports innovation in low-cost manufacturing processes such as additive and digital manufacturing. As a part of this initiative, NASA is developing and manufacturing ultra-lightweight materials for aerospace vehicles to demonstrate lower-mass alternatives to honeycomb or foam cores currently used in composite sandwich structures. NASA is one of the following participating agencies in the NNMI, the Department of Defense, Department of Energy, Department of Commerce's National Institute of Standard and Technology (NIST), the National Science Foundation, and the Department of Education.

NATIONAL ROBOTICS INITIATIVE

The goal of the National Robotics Initiative is to accelerate the development and use of robots in the United States that work beside or cooperatively with people. Space Technology supports the National Robotics Initiative by issuing grants for robotics technologies that benefit space exploration as well as support manufacturers, businesses, and other entities. Innovative robotics research and applications emphasizing the realization of such co-robots working in symbiotic relationships with human partners is supported by multiple agencies of the federal government. In addition to NASA, the list includes the National Science Foundation (NSF), the National Institutes of Health (NIH), the U.S. Department of Agriculture (USDA), and the U.S. Department of Defense (DoD).

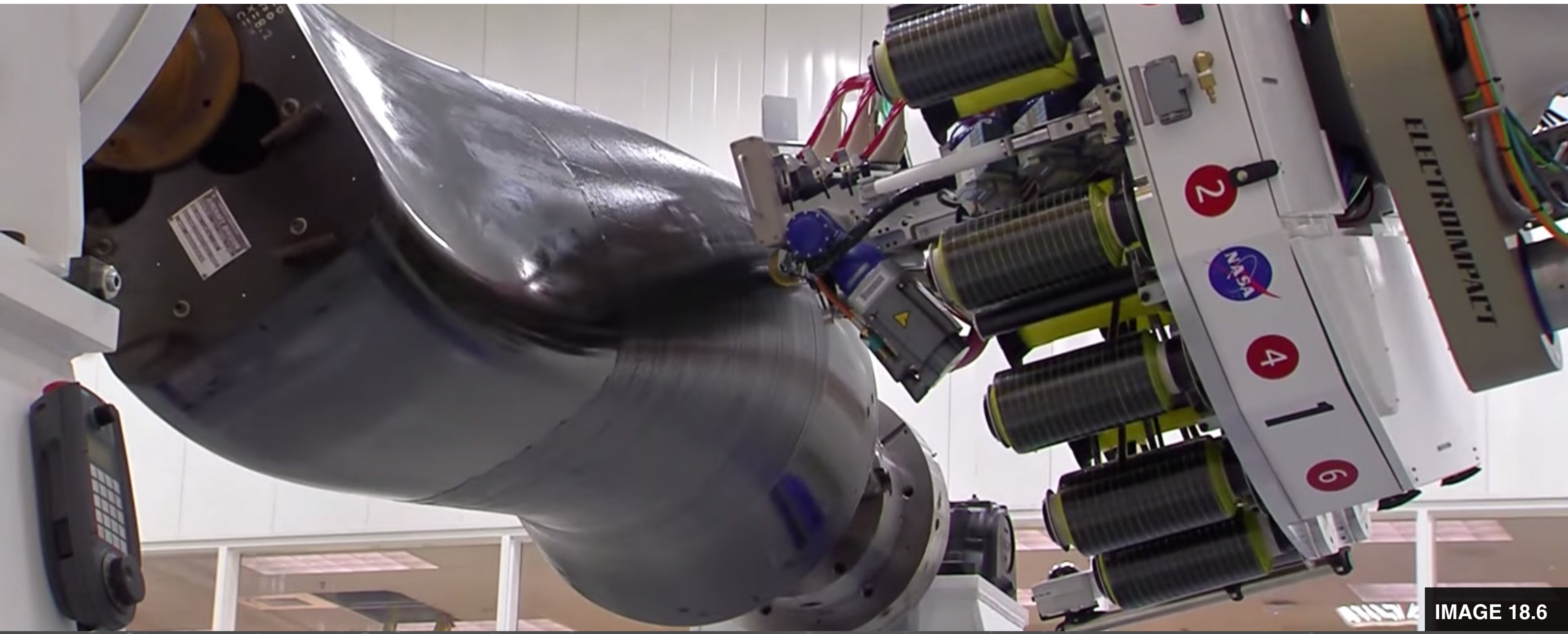


IMAGE 18.6

NATIONAL NANOTECHNOLOGY INITIATIVE (NNI)

The NNI is a U.S. government research and development (R&D) initiative involving the nanotechnology-related activities of 20 departments and independent agencies. Space Technology is exploring nanotechnology research and applications for aeronautics and space, with a focus on reducing vehicle mass and improving reliability through the development of carbon nanotube-based materials. This includes investments in nano-manufacturing through the development of carbon nanotube structural materials, and lightweight carbon nanotube/aerogel wires, and cables. The NNI brings together the expertise needed to advance this broad and complex field—creating a framework for shared goals, priorities, and strategies that helps each participating Federal Agency leverage the resources of all participating agencies.

MATERIALS GENOME INITIATIVE

The Materials Genome Initiative is a multi-Agency initiative designed to create a new era of policy, resources, and infrastructure that support U.S. institutions in the effort to discover, manufacture, and deploy advanced materials twice as fast and at a fraction of the cost. NASA, in close collaboration with NIST, established the MaterialsLab program on the International Space Station (ISS). The MaterialsLab is accelerating the development of higher-performing materials and processes for use both in space and on Earth, offering unique insights into how materials develop and behave in the microgravity environment. By sharing the results through NASA's open Physical Sciences Informatics data repository, researchers—including students—can easily access data from ISS experiments and build on each other's work.

ADDITIONAL RESOURCES

- WWW [NASA Spinoff Technology Transfer Program]
- WWW [Space Technology]
- [STMD Technology Drives Exploration]
- [NASA Space Technology Youtube Playlist]

MISSION SUPPORT DIRECTORATE (MSD)

MISSION STATEMENT

The Mission Support Directorate (MSD) oversees the critical mission support resources and services across the nine NASA field centers and ensures NASA accomplishes the mission by effectively managing people, technical capabilities, and infrastructure. MSD focuses on reducing institutional risk to NASA's current and future missions by improving processes, stimulating efficiency, and providing consistency and uniformity across institutional capabilities and services.

The MSD strategic mission objectives include: 1) Stewardship of resources and major institutional operations to support successful accomplishment of mission objectives, 2) Integration of resources, infrastructure, processes, and advocacy for institutional capabilities and needs for NASA, and 3) Optimizing mission support services through strategic analysis and Business Services Assessments (BSA) to enable more efficient operations for NASA.

OFFICE WEBSITE *http://www.nasa.gov/msd*

IMAGE 19.1

MISSION SUPPORT DIRECTORATE CORE FUNCTIONS

INTEGRATION OF MISSION SUPPORT ACTIVITIES
Integrates and aligns Agency-wide mission support activities. Oversees Agency functional leadership capabilities including the Office of Human Capital Management, Office of Protective Services, Office of Procurement, Office of Strategic Infrastructure, NASA Shared Services Center, and Headquarters Operations (Headquarters as a Center). Core functions of each office provided separately.

AGENCY PARTNERSHIP PROGRAM
Provides administration for the Agency's external partnership function (excluding international and classified partnerships).

NASA POLICY AND DIRECTIVES
Leads the establishment and maintenance of Agency policies and directives and verifies regulatory compliance.

AGENCY INSTITUTIONAL FUNDS MANAGEMENT
Serves as control account manager and decision authority for institutional program funds across the Agency. Manages, allocates, and evaluates program performance for the Safety, Security, and Mission Services (SSMS) and Construction and Environmental Compliance and Restoration (CECR) appropriations.

NASA AUDIT LIAISON WITH OFFICE OF THE INSPECTOR GENERAL AND GOVERNMENT ACCOUNTABILITY OFFICE
Manages, tracks, and reports on the Agency's audit resolution and follow-up activities.

MISSION SUPPORT DIRECTORATE ORGANIZATION

The Mission Support Directorate (MSD) is comprised of the Office of the Associate Administrator and seven offices. Five of the offices manage Agency-wide functional areas including Human Capital Management, Strategic Infrastructure, Procurement, Protective Services, and the NASA Shared Services Center (NSSC). The NSSC is an Agency-wide shared service and support center located at the Stennis Space Center in Mississippi. The Office of Headquarters Operations ensures NASA Headquarters has the facilities, services, and resources to support Headquarters as a Center. The Office of Resources and Performance Management oversees and manages Agency-level integration of mission support budgets and performance.

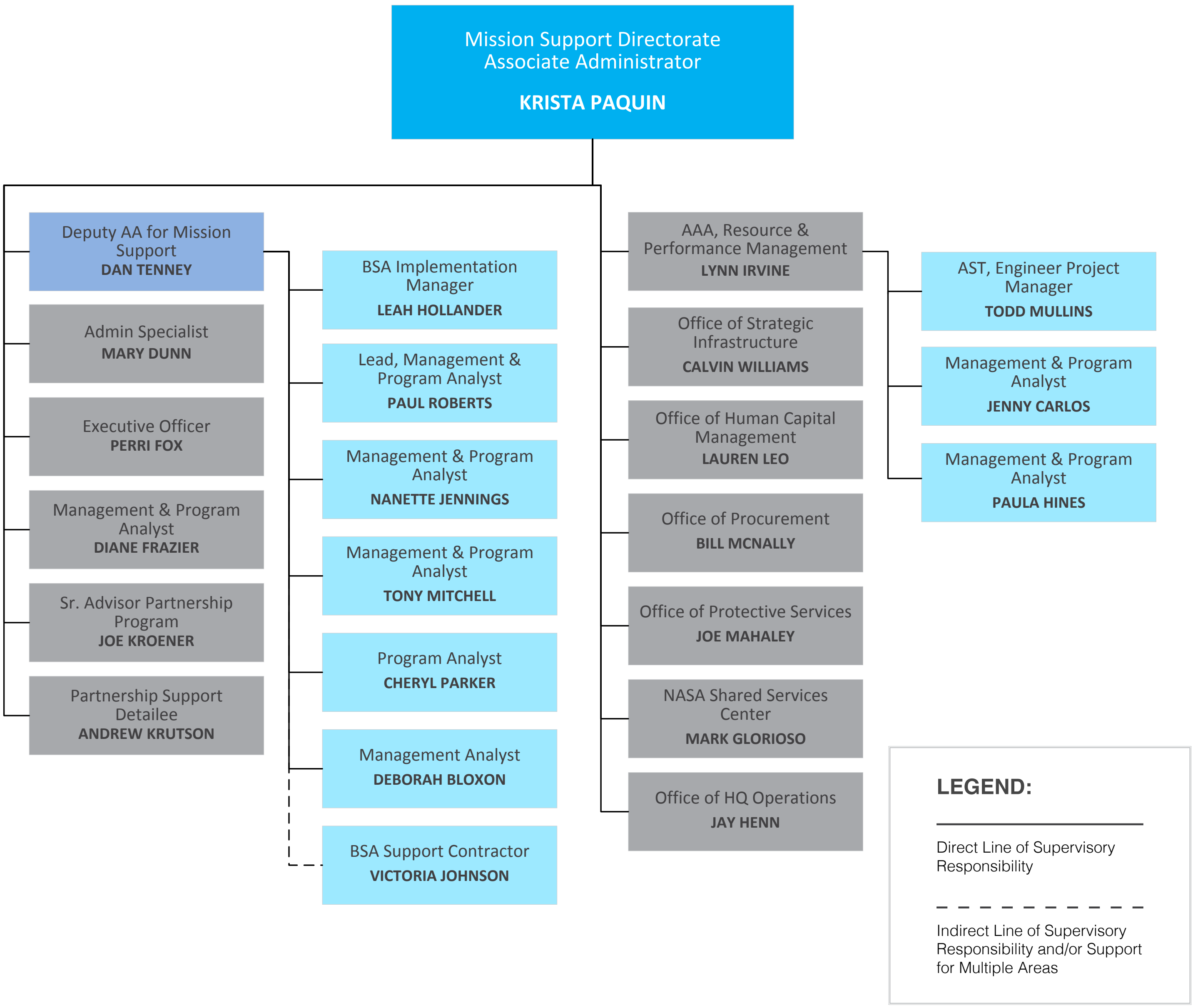


Figure 19.1 Mission Support Directorate (MSD) Organization Chart

ASSOCIATE ADMINISTRATOR
KRISTA C. PAQUIN

Krista Paquin is the Associate Administrator for the Mission Support Directorate. She was appointed to this position in April 2015. She started her career at Goddard, in 1984 and during her tenure there she progressed to executive positions in engineering, flight projects, and administration. Prior to leaving Goddard in 2006, she served as the Center Associate Director. From 2006 to 2010, Ms. Paquin served as the NASA Assistant Associate Administrator and Deputy of the Office of Program and Institutional Integration at NASA HQ. She left NASA in 2010 for an executive position in a high tech small business. She returned to NASA in May 2014 as Deputy Associate Administrator for Mission Support Directorate. She holds BA and MA degrees in Urban Planning and Management from the University of Maryland.

EXTENDED BIO - *http://www.nasa.gov/msd/msd-leadership*

DEPUTY ASSOCIATE ADMINISTRATOR
DANIEL J. TENNEY

Daniel Tenney has over 23 years of professional, leadership, and executive experience with the federal government and has served as the Deputy Associate Administrator for Mission Support Directorate since 2015. Prior to this position he was the Chief Financial Officer (CFO) at the NASA Langley Research Center, and he managed the Management and Technical Support Office at the NASA Engineering and Safety Center (NESC). In 2003, Mr. Tenney was asked to serve as the Deputy Director for Full Cost Operations where he led NASA as the first Federal Agency to implement Agency-wide full cost operations. He earned a Bachelor's Degree in Accounting from Christopher Newport University and a Master's Degree in Business Administration from Averett University.

EXTENDED BIO - *http://www.nasa.gov/msd/msd-leadership*

IMAGE 19.2

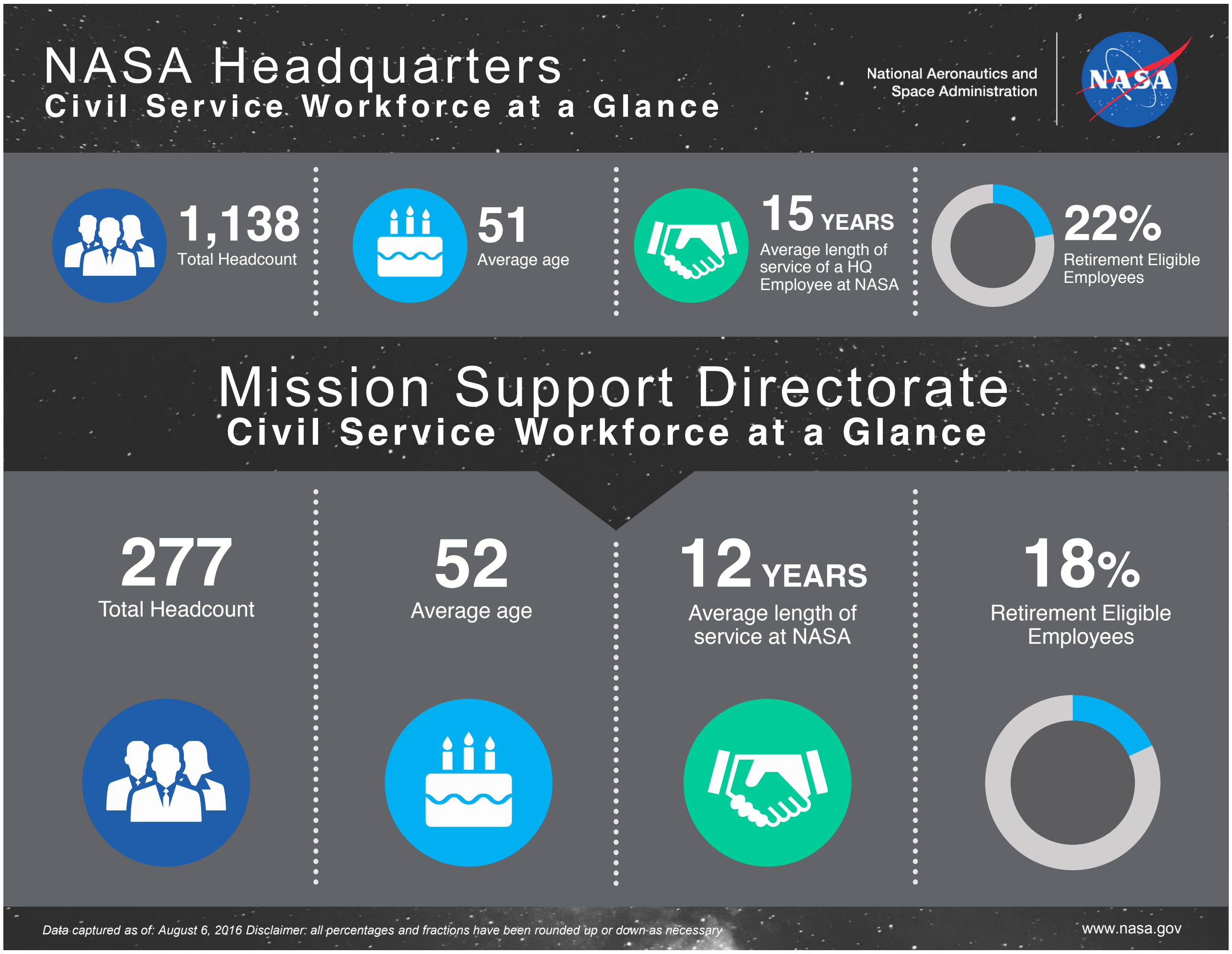


Figure 19.2 Mission Support Directorate Workforce at a Glance

IMAGE 19.3

BUSINESS SERVICES ASSESSMENT (BSA)

Through the execution of the BSA, NASA is defining the health of each business service area, identifying opportunities for optimization, and developing risk-informed recommendations to establish a more efficient operating model that maintains a minimum set of capabilities and meets current and future mission needs. MSD leads and manages this Agency assessment of Agency mission support services. By engaging the mission support functions and key customers and stakeholders through the BSA, NASA is defining the health of each business service area, identifying goals and opportunities for optimization and leveraging of capabilities, and developing risk-informed decision packages. This is being done in a manner that maintains transparency and involves stakeholders throughout the process. This disciplined method enables NASA leadership to make informed decisions on investing/divesting strategically within constrained institutional budgets while strengthening innovation in critical areas needed to advance our mission.

QUARTERLY STRATEGIC LEADERSHIP FORUM FOR ASSOCIATE CENTER DIRECTORS AND ASSISTANT ADMINISTRATORS

Established in 2014, the Strategic Leadership forums provide regular and ongoing communication channels to actively engage mission support principals to enable effective cross-center collaboration, identify and characterize risk, and coordinate ongoing and future mission support activities across the Agency. The team shares leadership responsibility to resolve complex interdependent Agency institutional challenges, and mitigate institutional risks for NASA. The forums provide a strategic and executive-level construct to integrate activities across functional areas, share promising practices, jointly problem solve, coordinate inter-Agency initiatives and activities, and establish future direction for institutional areas across NASA.

QUARTERLY CUSTOMER PROGRAM PERFORMANCE REVIEWS OF NASA SHARED SERVICES CENTER (NSSC)

As a key element of NSSC governance, these reviews were established in 2016. The purpose is to: 1) review NSSC performance, cost, rates, and investments; 2) provide a flexible and adaptive process to ensure that customer focus, advocacy, communication, and performance are continuously assessed; 3) ensure that the correct performance measures are identified and reported to the Agency; 4) increase client confidence in the validity of the performance results being reported; 5) provide stakeholders with a forum to provide feedback and, in turn, enhance the overall NSSC experience; and 6) build advocacy for new work transitions in the future.

HEADQUARTERS STRATEGIC WORKFORCE COMPLEMENT MANAGEMENT

Seeks to establish a stronger and more collaborative construct to strategically plan and manage workforce at the Headquarters level. The process focuses on grouping similar organizations and developing a forward-filling strategy that aligns future skills with Agency strategic direction instead of a traditional backfilling approach. The purpose of the Baseline Complement Review is to identify opportunities to enable more effective and efficient operations across HQ, evaluate how resources are aligned with future needs, and to establish new organization ceilings. The initial workforce Baseline Complement Review will conclude during the first quarter of FY 2017 and is designed as a precursor to implementing the new management process in FY 2017.

! ADDITIONAL RESOURCES

www [Headquarters Operations Website]

MSD: NASA SHARED SERVICES CENTER (NSSC)

MISSION STATEMENT

The NASA Shared Service Center (NSSC) performs select transactional and administrative activities for NASA Centers in human resources, financial management, procurement, business support, and information technology support services. The NSSC is located on the grounds of NASA's Stennis Space Center (SSC) in Hancock County, Mississippi.

OFFICE WEBSITE - *https://www.nssc.nasa.gov/for-public*

IMAGE 20.1

NASA SHARED SERVICE CENTER CORE FUNCTIONS

HUMAN RESOURCES SERVICES

The NSSC provides human resources services that provide support to personnel programs, SES Case Documentation, Employee Development and Training, Employee Benefits, Financial Disclosure Processing, Human Resources Information Training Systems Operations and Maintenance, Personnel Action Processing, eOPF Maintenance and Record Keeping, Online Course Management, and Off-Site Training Purchases.

FINANCIAL MANAGEMENT SERVICES

The NSSC provides Accounts Payable, Accounts Receivable, Travel, and Fund Balance with Treasury services for NASA Centers and Headquarters Additionally, the NSSC provides services for Extended Temporary Duty Assistance, Relocation Services, and support for the Agency Travel/Fleet Card Programs.

PROCUREMENT SERVICES

The NSSC provides a variety of procurement services across NASA to satisfy the evolving acquisition needs of the Agency.

BUSINESS SERVICES

The NSSC provides services through the Enterprise Service Desk, which consists of a Tier-1 Service Desk and Tier-0 Website that support the Agency's Infrastructure Integration Program and other Center-specific and Program-specific initiatives.

INFORMATION TECHNOLOGY SUPPORT SERVICES

The NSSC provides business support services to the Agency's Information Technology Business Services.

EXECUTIVE DIRECTOR

MR. MARK V. GLORIOSO

Mark V. Glorioso serves as the Executive Director of the NASA Shared Services Center (NSSC) in Hancock County, Mississippi, where he leads a team of more than 550 civil service and service provider employees. Mr. Glorioso joined the NSSC March 17, 2014.

As Executive Director of a multi-function shared services center, which includes financial management, information technology, human resources, procurement services, and business support services, Mr. Glorioso provides Agency services to NASA employees, contractors, grantees, and vendors. In this capacity, he manages the NSSC's operating budget of $59.2 million and approximately $388.2 million in additional Agency-provided funding for training and initiatives of benefit across the Agency.

EXTENDED BIO *- https://searchpub.nssc.nasa.gov/servlet/sm.web.Fetch/Mark_V__Glorioso_Bio_4_2_14.pdf?rhid=1000&did=1806397&type=released*

IMAGE 20.2

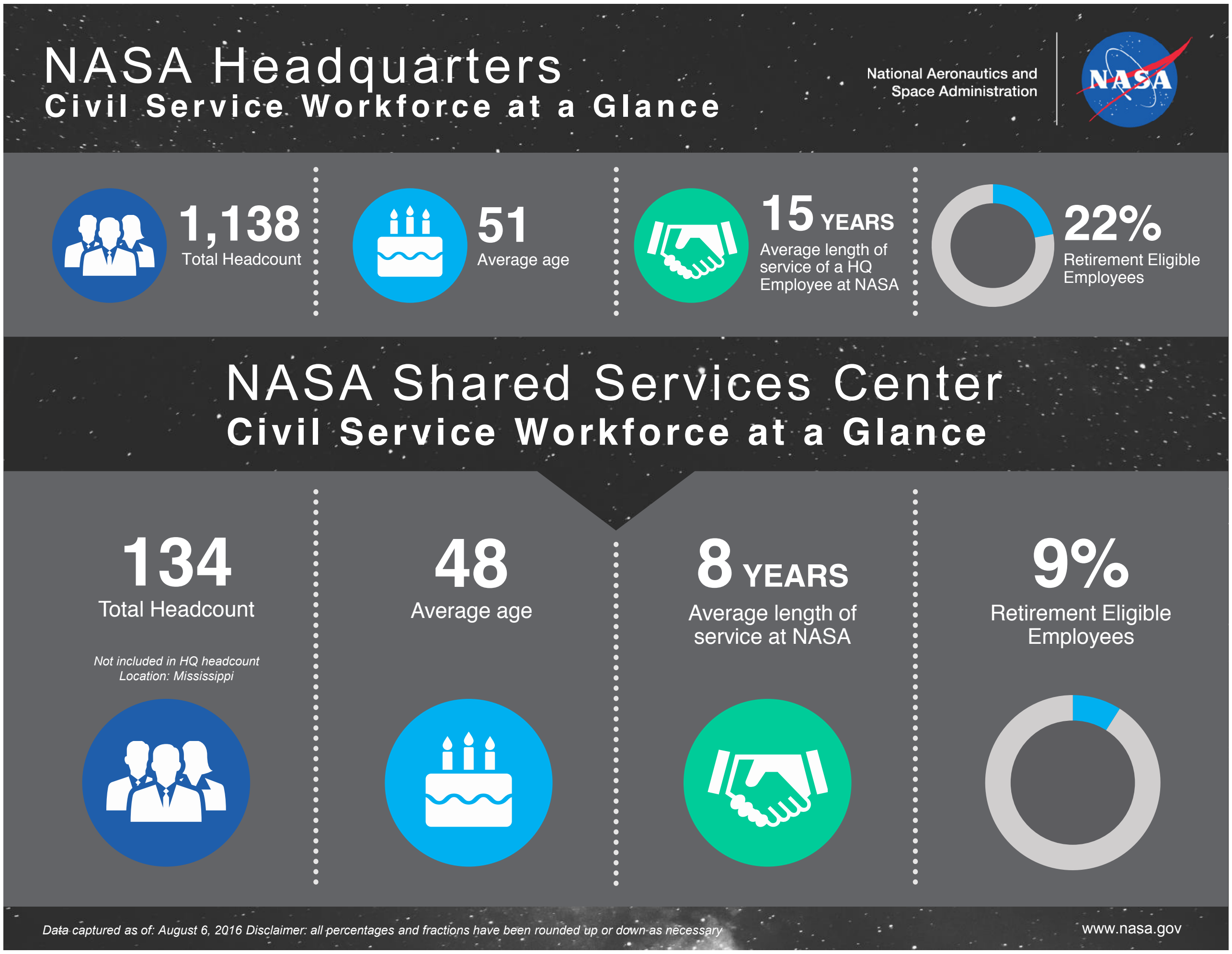


Figure 20.1 NASA Shared Services Center Workforce at a Glance

ADDITIONAL RESOURCES

[NSSC Brochure]

MSD: OFFICE OF HEADQUARTERS OPERATIONS (HQOP)

MISSION STATEMENT

The Office of Headquarters Operations provides executive leadership and oversight for services and products necessary to support effective operations of the NASA Headquarters facility. This Headquarters office serves as the single focal point on matters pertaining to the planning, management, execution, and evaluation of Headquarters institutional management services and activities.

OFFICE WEBSITE *- http://hqoperations.hq.nasa.gov/index.html*

IMAGE 21.1

OFFICE OF HEADQUARTERS OPERATIONS CORE FUNCTIONS

FACILITIES AND ADMINISTRATIVE SERVICES

Facility Management, Emergency Management, Continuity of Operations, and Safety and Health Services.

INFORMATION TECHNOLOGY AND COMMUNICATION

Desktop Hardware and Software Acquisition, Application and Software Development, IT Project Management, IT Security Services, Records Management, Telephone Voice Communications, Graphics, Photographic and Printing/Duplication Services.

EQUAL OPPORTUNITY AND DIVERSITY MANAGEMENT

Alternative Dispute Resolution, EO Counseling, Affirmative Employment, Diversity/Special Emphasis Programs, and Reasonable Accommodations.

HUMAN RESOURCES MANAGEMENT

Executive Resources, Recruitment, Staffing and Placement, Classification, Compensation, Position Management, Awards and Recognition, Labor and Employee Relations, Performance Management, Strategic Workforce Planning, Executive Leadership, Supervisory Training, Academic/On-site Classes, Executive Coaching, Mentoring, Employee and Organization Development, and Learning Consultation Services.

BUDGET MANAGEMENT AND SYSTEMS SUPPORT

Agency Management Budget Formulation and Execution, Travel, Financial, and e-Government Systems.

EXECUTIVE DIRECTOR

MR. JAY M. HENN

Jay M. Henn has served as Executive Director for Headquarters Operations since August, 2011. In his 28-year NASA career, he has also served as Deputy Assistant Administrator for Human Capital Management, Assistant Associate Administrator for Operations in the Aeronautics Enterprise; Director for Management Programs in the Office of Aeronautics and Space Transportation Technology; and Director for Strategy and Policy in the Office of Aeronautics. He holds a B.A. with Honors in anthropology from the University of Arizona, an M.A. in archaeology from Harvard University, an MBA from the Harvard Business School, and is a Distinguished Graduate of the Industrial College of the Armed Forces.

EXTENDED BIO - *http://hqoperations.hq.nasa.gov/people.html*

OFFICE OF HEADQUARTERS OPERATIONS AT A GLANCE

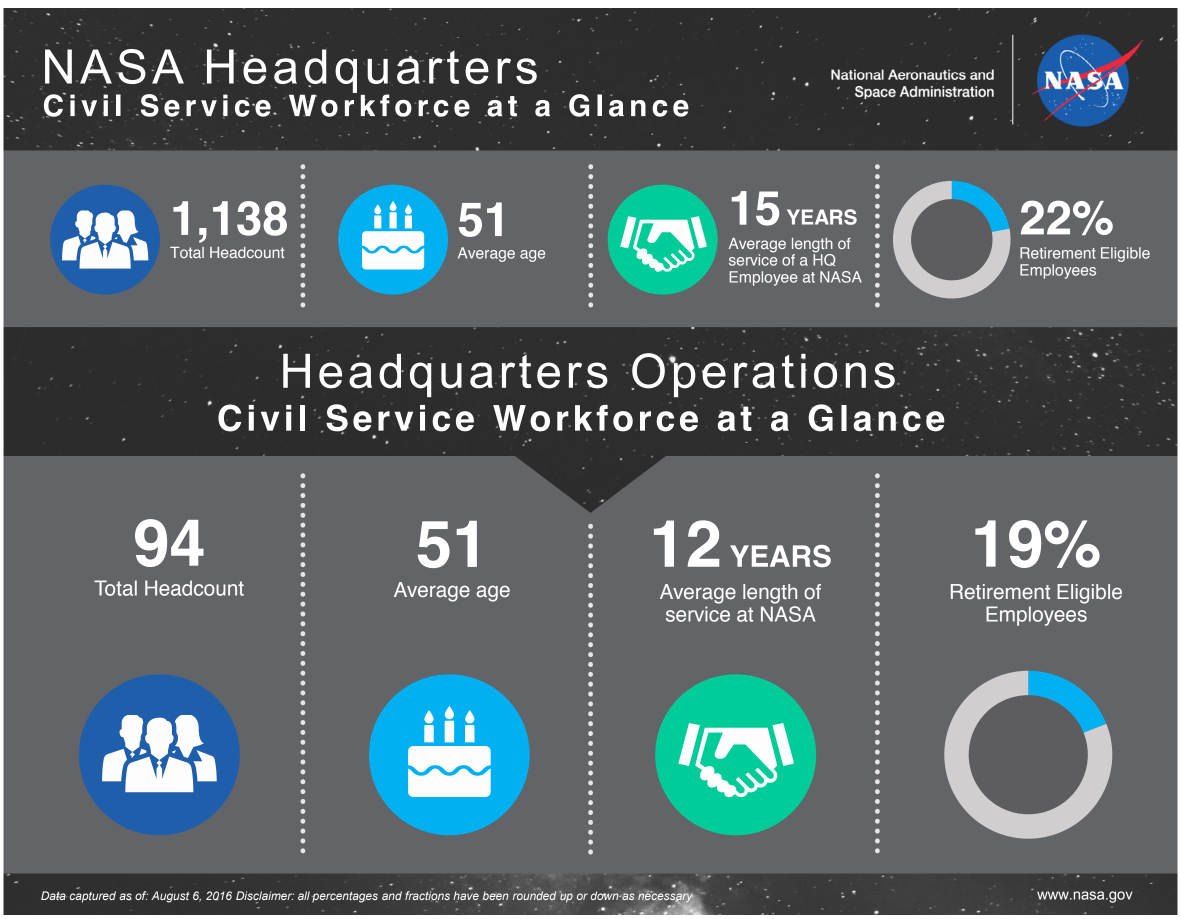


Figure 21.1 Office of Headquarters Operations Workforce at a Glance

HEADQUARTERS BOARD OF ADVISORS

The Headquarters Board of Advisors is an informal Headquarters-wide body that serves as a forum for discussing issues and possible actions that impact all organizations and employees at Headquarters. The Board provides a mechanism for enhancing communication, collaboration, and community throughout the building. The inaugural meeting for the Board was held April 27, 2016, and future meetings will be held quarterly.

EMPLOYEE ENGAGEMENT

Headquarters Operations is focused on serving the customers through the building and developing a sense of community across headquarters and its resident organizations to bring about a stronger, more positive sense of community. Efforts are underway to enhance communication and collaboration so that employees will become more engaged in their work and have a positive attitude about the work place. This will lead to a higher performing, more focused, more satisfied workforce.

BUILDING RENOVATION PROJECT

In FY-14 NASA completed the 2.5 year renovation project of the Headquarters (HQ) building at 300 E St SW, Washington DC. NASA has received value for every dollar spent by significantly increasing the quality of the work environment and increasing energy savings via the design process. Just a few examples are the new energy efficient LED lighting which reduced overall energy usage by 20%. The installation of a Variable Air Volume HVAC system greatly increased environmental comfort and energy efficiency by 15% within the building. Overall the project resulted in increased energy efficiency of over 35%, provided natural daylight to 75% of building occupants, and improved workflows. The building was certified by the U.S. Green Building Council as a LEED Gold Construction Interiors.

ADDITIONAL RESOURCES

www [HQ Operations Website]

MSD: OFFICE OF HUMAN CAPITAL MANAGEMENT (OHCM)

MISSION STATEMENT

The Office of Human Capital Management (OHCM) is responsible for developing and aligning NASA civil service workforce strategies, programs, policies, and processes with the Agency's mission, strategic goals, and desired performance outcomes. The OHCM establishes Agency-wide civil service workforce management policies, defines strategies and architectures, defines program objectives and top-level requirements, ensures statutory and regulatory compliance, ensures consistency across the Agency as appropriate, and monitors program performance. OHCM represents the Agency's interests in intergovernmental and other groups established to address workforce issues.

OFFICE WEBSITE - *http://nasapeople.nasa.gov/home.htm*

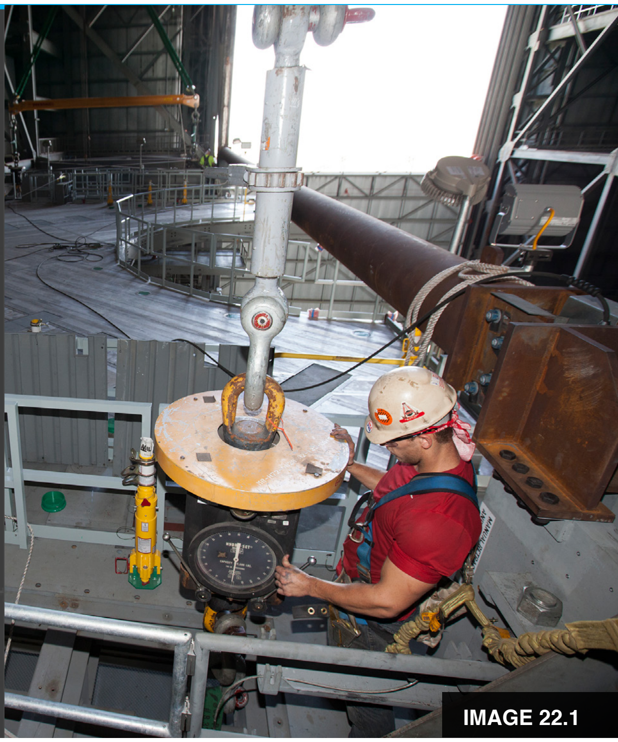


IMAGE 22.1

OFFICE OF HUMAN CAPITAL MANAGEMENT CORE FUNCTIONS

INTEGRITY
Uphold integrity of NASA's Human Capital Program while enabling maximum flexibility for implementation.

STRATEGY
Serve as strategic and technical advisors to Agency leadership and Center HR Offices.

IMPLEMENTATION
Implement Human Capital policies, programs, and applications that provide the support employees need to do their jobs in a way that fosters engagement and a sense of affiliation to the organization.

ANALYTICAL
Use data and feedback to learn from past experience and anticipate Agency and workforce needs.

ASSISTANT ADMINISTRATOR
LAUREN E. LEO

Ms. Lauren Leo is NASA's Chief Human Capital Officer and Asstistant Administrator for Human Capital Management. She advises the Administrator on all workforce related programs and policies. Her responsibilities include setting the Agency's workforce development strategy, assessing workforce characteristics and future needs, and aligning NASA's HC policies and programs with Agency mission. Prior to serving as the AA, Ms. Leo held increasingly responsible positions at the forefront of developing and implementing innovative workforce engagement and development strategies and programs. Ms. Leo holds an M.A. in International Relations with a certificate in International Conflict Resolution from the Maxwell School at Syracuse University and a B.A. in International Relations from Mary Washington College.

EXTENDED BIO *- http://www.nasa.gov/feature/lauren-leo-assistant-administrator-human-capital-management*

OFFICE OF HUMAN CAPITAL MANAGEMENT LEADERSHIP

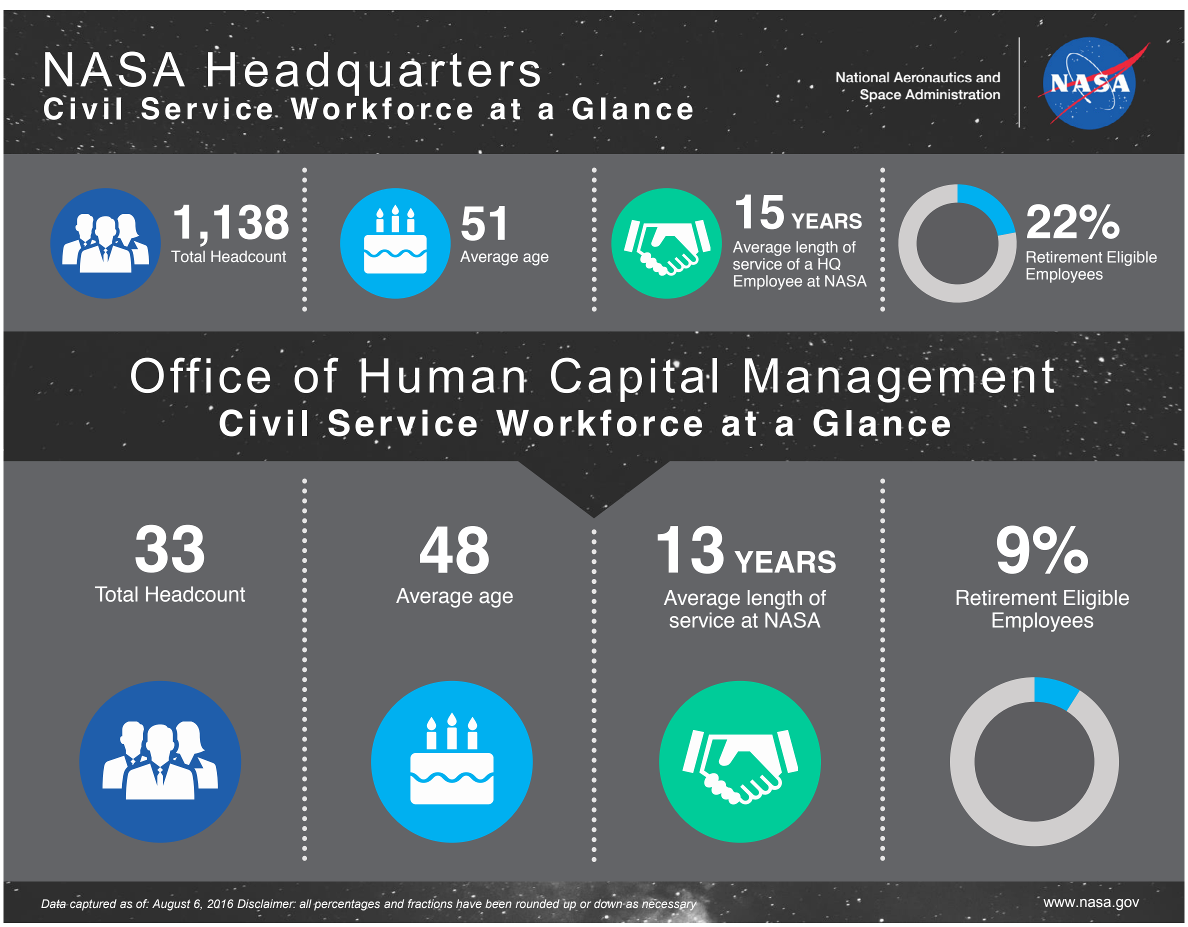


Figure 22.1 Office of Human Capital Workforce at a Glance

BUSINESS SERVICES ASSESSMENT (BSA)

Through the execution of the BSA, NASA is defining the health of each business service area, identifying opportunities for optimization, and developing risk-informed recommendations to establish a more efficient operating model that maintains a minimum set of capabilities and meets current and future mission needs. OHCM is in the process of building teams to implement BSA decisions to 1) Establish a Strategic Workforce planning Process and Capability; 2) Implement innovative approaches such as "digital recruiting" that leverage the "NASA brand" and a hiring process that is transparent to HR staff and hiring managers; 3) Consolidate most classification and staffing at the NSSC; 4) Implement a structured program for early career hires (including Pathways) to include a new "on boarding" program with Agency-wide focus; 5) Develop a structured approach for communicating, identifying, and filling supervisory or team lead positions; 6) Conduct Zero-Based-Review (ZBR) of Agency-wide training; 7) Conduct a ZBR of Organizational Development; and 8) Provide support structure for cross-organizational opportunities. These initiatives directly support BSA goals to improve consistency across the Agency and gain efficiencies in human capital management.

RECOGNIZING AND REWARDING INNOVATIVE PERFORMANCE

This plan focuses on finding ways to recognize and reward desired ways of working and desired behaviors while work is happening— creativity, innovation, collaboration, teamwork, etc.—rather than after it has been successfully completed. The purpose of this program is to reward and appreciate employees for their innovative performance and contributions to their workplace.

ENGAGING AND CONNECTING THE WORKFORCE

Truly engaged employees are likely to be NASA's best source of new ideas. They also are more productive, get better results, and operate more safely than less engaged employees. The single most important way to engage workers is to enable them to make progress in meaningful work. Fortunately, there's no shortage of meaningful work at NASA. OHCM programs engage employees in the NASA Mission and enable them to cooperate, collaborate and network with one another.

BUILDING MODEL SUPERVISORS AND LEADERS

Managers and leaders play a critical role in establishing and sustaining an innovative and creative culture. NASA has experienced steady improvement over the last decade in surveys that measure supervisory effectiveness. OHCM programs develop supervisors and leaders who view developing employees as an important and productive use of time.

! ADDITIONAL RESOURCES

WWW [NASA People]

MSD: OFFICE OF PROCUREMENT (OP)

MISSION STATEMENT

The Office of Procurement provides executive leadership, policy direction, and functional management of procurement and financial assistance activities (excluding Space Act Agreements) for the entire Agency.

OFFICE WEBSITE *- https://www.hq.nasa.gov/office/procurement/*

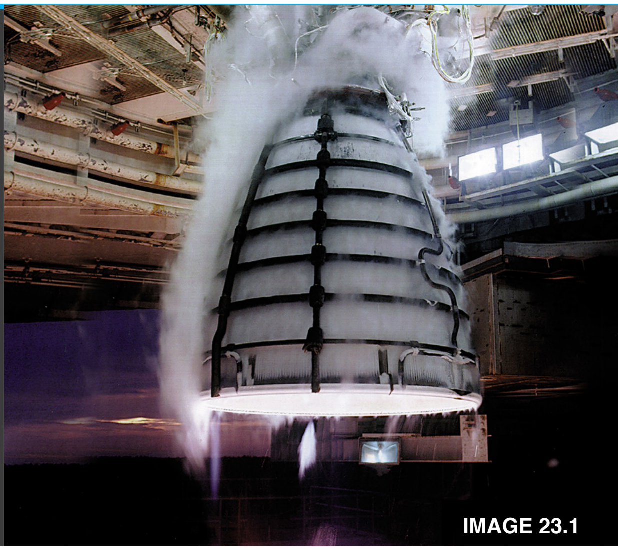


IMAGE 23.1

OFFICE OF PROCUREMENT CORE FUNCTIONS

EFFECTIVE MANAGEMENT OF CHANGES IN FEDERAL PROCUREMENT POLICY

Prescribe Agency-wide policies, strategies, regulations, and procedures governing the conduct of all NASA procurement and financial assistance activities (excluding the Space Act) within the framework of national and Agency policies and applicable laws and regulations.

ACQUISITION PLANNING

Manage the overall procurement strategy for major NASA acquisitions and ensure the timeliness and effectiveness of the full spectrum of NASA procurement and financial assistance functions (grants and cooperative agreements).

FEDERAL PROCUREMENT INITIATIVES

Implement Office of Management and Budget (OMB) initiatives assigned to the Office of Procurement, such as eGov requirements for procurement IT systems and Federal procurement data reporting initiatives, and provide reporting required by Congress and other external bodies.

CAREER DEVELOPMENT

Oversee the Agency procurement and Contracting Officer Representative training programs and the certification programs for procurement, Contracting Officer Representatives, and program and project managers.

OFFICE OF PROCUREMENT LEADERSHIP

ASSISTANT ADMINISTRATOR FOR PROCUREMENT

MR. BILL MCNALLY

Bill McNally is the Assistant Administrator for Procurement and Deputy Chief Acquisition Officer at NASA. He directs NASA's procurement functions throughout the Agency, providing strategic policy, leadership, and direction. He represents NASA procurement to the Executive and Legislative branches of the Federal government, industry, and international organizations. Mr. McNally was appointed as the Assistant Administrator for Procurement in September 2007.

EXTENDED BIO - *http://www.hq.nasa.gov/office/procurement/mcnallybio.html*

OFFICE OF PROCUREMENT AT A GLANCE

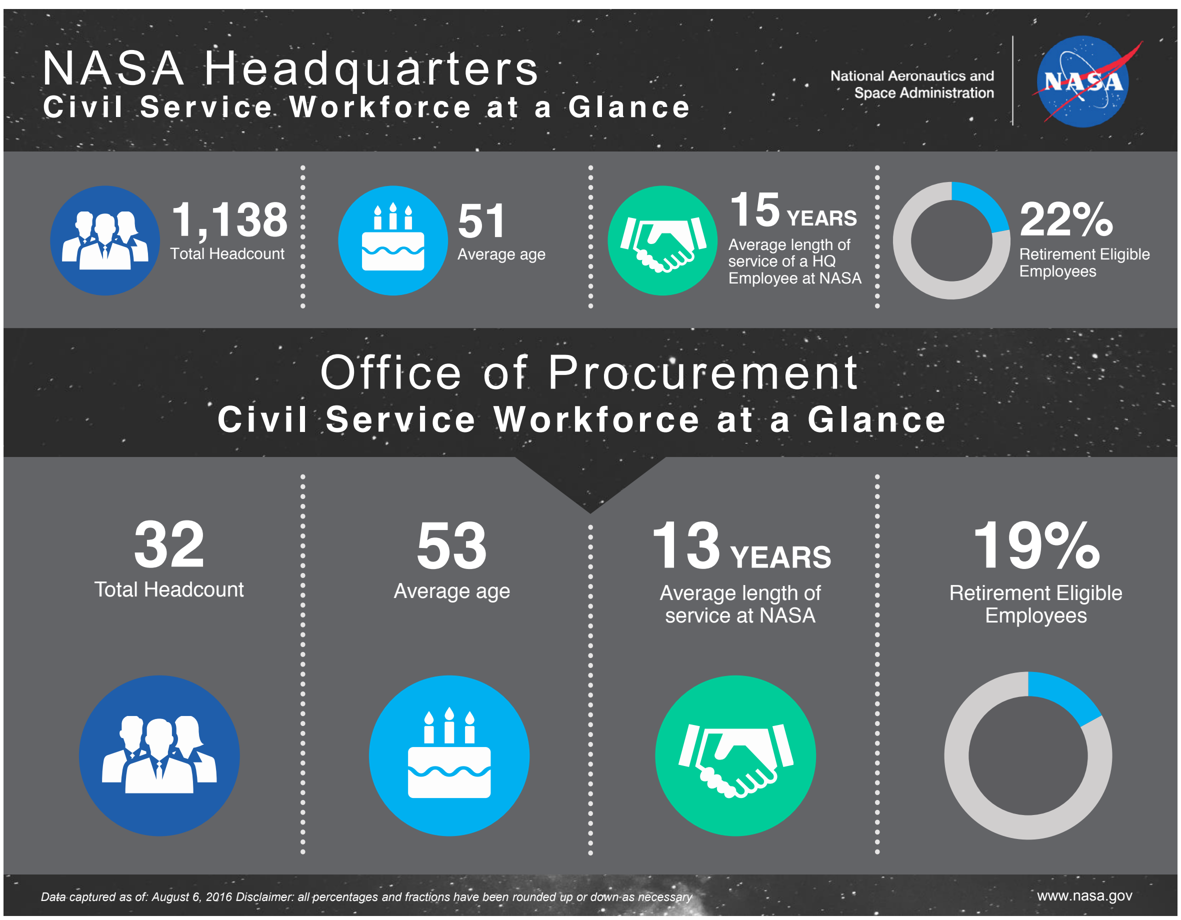


Figure 23.1 Office of Procurement Workforce at a Glance

BUSINESS SERVICES ASSESSMENT (BSA)

Through the execution of the BSA, NASA is defining the health of each business service area, identifying opportunities for optimization, and developing risk-informed recommendations to establish a more efficient operating model that maintains a minimum set of capabilities and meets current and future mission needs. NASA performed a BSA Deep Dive review of the Procurement function in 2015. The Deep Dive included review of workforce practices, governance, and policy. The resulting efficiency initiatives should reduce transactional costs and resources required to support the procurement business process. To reduce the lengthy process required to strengthen policies and codify procurement regulations, Procurement established a policy operating guide in June 2015. This is a living document with its last update in February 2016.

PAPERLESS INITIATIVE

NASA's Paperless initiative was first introduced in November 2013. The initiative offers the opportunity to streamline award processes, ending the need for Center-unique procurement software that does not support the Enterprise. It will provide e-Signature capability for NASA contract and financial assistance awards, archive and destruction capabilities, procurement workload management, and the capability to directly interface with Federal data systems. SAP's Procurement for Public Sector (PPS) software was selected by NASA to support the Agency-wide deployment scheduled for March 2017.

IMAGE 23.2

MSD: OFFICE OF PROTECTIVE SERVICES (OPS)

MISSION STATEMENT

The Office of Protective Services (OPS) serves as the focal point for policy formulation, oversight, coordination, and management of the Agency Protective Services, fire and security services, counterintelligence (CI), counterterrorism (CT), emergency management planning, and continuity of operations functions.

OFFICE WEBSITE *- http://www.hq.nasa.gov/office/ops/nasaonly/index.html*

IMAGE 24.1

OFFICE OF PROTECTIVE SERVICES CORE FUNCTIONS

THE OFFICE OF PROTECTIVE SERVICES IS RESPONSIBLE FOR THE POLICY AND OVERSIGHT OF AGENCY-WIDE:

- Security Management
- Counterintelligence/Counterterrorism (and Operational Control)
- Foreign National Access Management
- Electronic Physical Access Control System (EPACS)
- Identity, Credential, and Access Management (ICAM) (and Operational Control)
- Special Access Programs (SAP)
- Insider Threat Program (and Operational Control)
- Emergency Management and Continuity of Operations (COOP) Program (and Operational Control)
- NASA Protective Services Training Academy (NPSTA) (and Operational Control)
- Communications Security (COMSEC)

OFFICE OF PROTECTIVE SERVICES LEADERSHIP

ASSISTANT ADMINISTRATOR
JOSEPH S. MAHALEY

Joe Mahaley is the Assistant Administrator (AA) for Protective Services at NASA. He leads the Office of Protective Services (OPS) and is the focal point for policy formulation, oversight, coordination, and management of the Agency's protective services. As the AA for OPS, he oversees NASA's security management, intelligence analysis, counterintelligence/counterterrorism (CI/CT) services, national security systems, handling of sensitive and classified information, identity, credential, and systems management, emergency management, and continuity of operations functions. He is also NASA's Insider Threat Senior Official.

Mr. Mahaley is the former Director of Security and Emergency Operations at the U.S. Department of Energy (DOE) and has over 35 years of experience in the government, military and private sectors.

EXTENDED BIO - *http://www.nasa.gov/about/highlights/mahaley_bio.html*

OFFICE OF PROTECTIVE SERVICES AT A GLANCE

Figure 24.1 Office of Protective Services Workforce at a Glance

FOREIGN NATIONAL ACCESS MANAGEMENT (FNAM) PROGRAM

Collaboration with foreign nationals representing international partners ensures NASA's mission and vision are supported by the best and brightest the world has to offer in a multitude of engineering and science disciplines. The FNAM Program is NASA's primary vehicle for strengthening the systemic management of foreign national access across the Agency. Led by the Office of Protective Services (OPS) and with cooperation from the Office of International and Interagency Relations (OIIR) and the Office of the Chief Information Officer (OCIO), the FNAM Program's overarching goal is to minimize risks to NASA's critical infrastructure (facilities, technology, and information) through the management of physical and logical access by foreign nationals and ensuring compliance with U.S. laws and regulations.

NASA'S INSIDER THREAT PROGRAM

In October 2011, the President issued Executive Order (EO) 13587 establishing the National Insider Threat Task Force (NITTF). The primary mission of the NITTF is to prevent, deter, and detect compromises of classified information by malicious insiders. As part of the EO, the President directed Federal departments and agencies with classified networks, to establish Insider Threat detection and prevention programs. The EO was further implemented by a Presidential Policy Memorandum in November 2012 setting minimum standards for Executive Branch Insider Threat Programs. NASA has made great strides in implementing its Insider Threat Program (ITP), such as designating a Senior Agency Official to be responsible for the ITP (Assistant Administrator for Protective Services), developing a formal ITP policy document, implementing ITP training for clearance holders, establishing user activity monitoring on at least one classified IT system, and standing up an ITP reference website. Full Operational Capability (FOC) for NASA's ITP will be completed by the Federal deadline of December 31, 2016. A comprehensive ITP is essential to the safety and security of our NASA employees, contractors, property, infrastructure, and information by helping to detect and deter the efforts of malicious insiders.

IMAGE 24.2

CONTINUED ENHANCEMENT OF NASA COUNTERINTELLIGENCE (CI) AND COUNTERTERRORISM (CT) CAPABILITIES

Without a robust defensive CI/CT program at Headquarters and at the Centers constantly monitoring threats and developing and implementing initiatives to detect/deter/neutralize acts of terrorism, espionage, sabotage, and intelligence gathering, NASA's personnel and technologies would be vulnerable. NASA has made significant improvements to the CI/CT infrastructure in recent years and continues to enhance our Agency-wide CI/CT defensive capabilities in order to protect our workforce, information, facilities, and programs.

IDENTITY CREDENTIAL AND ACCESS MANAGEMENT (ICAM) MODERNIZATION

The systems comprising the ICAM infrastructure are the sole and authoritative source for the enrollment and processing of NASA identity data and for the processing of access requests and the issuance of credentials used for access. Significant updates completed in FY 2016 include migration to a new access management infrastructure, deployment of new identity management business processes for Position Designation, and electronic access control plans for foreign national access management (FNAM). Further updates to ICAM will occur in FY 2017 and FY 2018 and include deployment of an Agency visitor management system and a suite of personnel security case management tools to manage Office of Personnel Management investigations and National Security Clearances.

IMAGE 24.3

MSD: OFFICE OF STRATEGIC INFRASTRUCTURE (OSI)

MISSION STATEMENT

The Office of Strategic Infrastructure (OSI) provides executive and functional leadership, policy, institutional authority, and oversight for Agency infrastructure. The Office's mission is to ensure that the right infrastructure assets and capabilities are available in the timeframe needed by reducing current and future infrastructure related risks to the Agency.

OFFICE WEBSITE *- http://osi.hq.nasa.gov/*

IMAGE 25.1

OFFICE OF STRATEGIC INFRASTRUCTURE CORE FUNCTIONS

AGENCY FACILITIES MANAGEMENT
Management of facility design and construction, facility maintenance and repair, facility operations, facility utilization, and real estate acquisition and disposal. Management of the Construction of Facilities (CoF) program.

MANAGES AGENCY AIRCRAFT ACTIVITY
Management of the acquisition, utilization, operations, safety, airworthiness, quality assurance, modification, control, and disposition of all NASA aircraft including Unmanned Aerial Systems (UAS). Serves as the Agency Aircraft Capabilities Leader.

MANAGES AGENCY INSTITUTIONAL AUTHORITY FOR LOGISTICS MANAGEMENT
Supply/material and inventory management, equipment management, property disposal management, contract property, transportation and fleet management, and logistics and supply chain management.

MANAGES AGENCY ENVIRONMENTAL PROGRAMS
Management of environmental stewardship and sustainability, development and dissemination of environmental Agency policies for: planning, compliance, restoration, pollution prevention, energy and water conservation, renewable energy generation and natural, cultural, and historic resource preservation. Management of the Environmental Compliance and Restoration (ECR) program.

MANAGES SPACE ENVIRONMENT TEST CAPABILITIES
Ensure NASA's space environment testing capabilities support current and future Agency and national needs. Portfolio assets managed include all major space environment testing assets, high-enthalpy material testing (Arc Jets), and flight simulation capabilities.

PROVIDES LEADERSHIP, OVERSIGHT, AND SUPPORT OF THE NASA OMBUDS PROGRAM
Offers the workforce a supplemental channel for communicating issues and concerns potentially impacting safety, organizational performance, or mission success.

ASSISTANT ADMINISTRATOR FOR STRATEGIC INFRASTRUCTURE

MR. CALVIN WILLIAMS

Prior to becoming Assistant Administrator in 2014, Mr. Williams served as the Director for Integrated Asset Management Division, where he was responsible for managing the Agency's real property, Agency facility master planning and the Strategic Capabilities Asset Program. Before coming to NASA in 2002, Williams served as the Program Manager, Business Manager, and Management Representative for ISO 9001 in the Division of Engineering Services at the National Institutes of Health (NIH) and worked as a Program Manager at the Chesapeake Division at the Naval Facilities Engineering Command where he was responsible for managing energy and other facility engineering projects.

EXTENDED BIO - *http://osi.hq.nasa.gov/bio_williams.html*

DEPUTY ASSISTANT ADMINISTRATOR FOR STRATEGIC INFRASTRUCTURE

MR. RICHARD "RICK" MARRS

Prior to joining NASA in early 2015, Mr. Marrs served as the senior civilian facilities engineer on the Staff of the Commandant of the Marine Corps for four years. As the Deputy Facilities Director, he oversaw policy development, budget formulation, and execution to support Facilities Sustainment, Repairs and Operations, Construction, Environmental Programs, Real Estate, Asset Management, Facilities Planning, Housing, Energy Management, and Utilities at 24 installations.

EXTENDED BIO - *http://osi.hq.nasa.gov/bio_marrs.html*

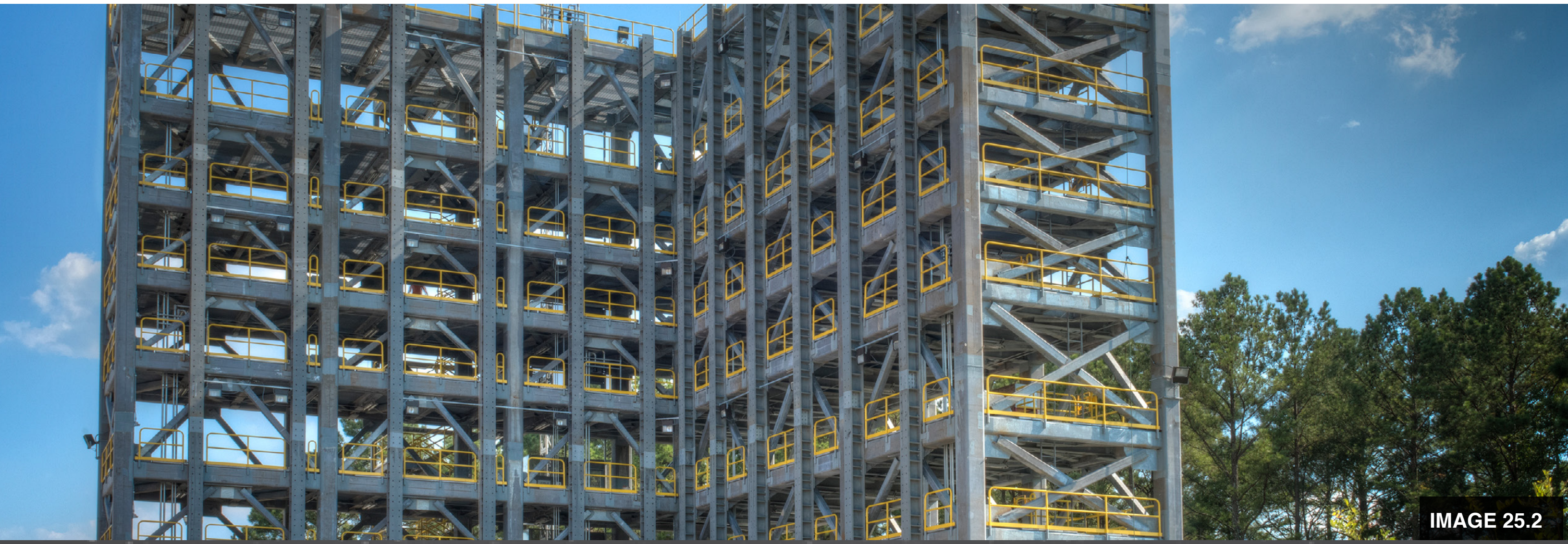


IMAGE 25.2

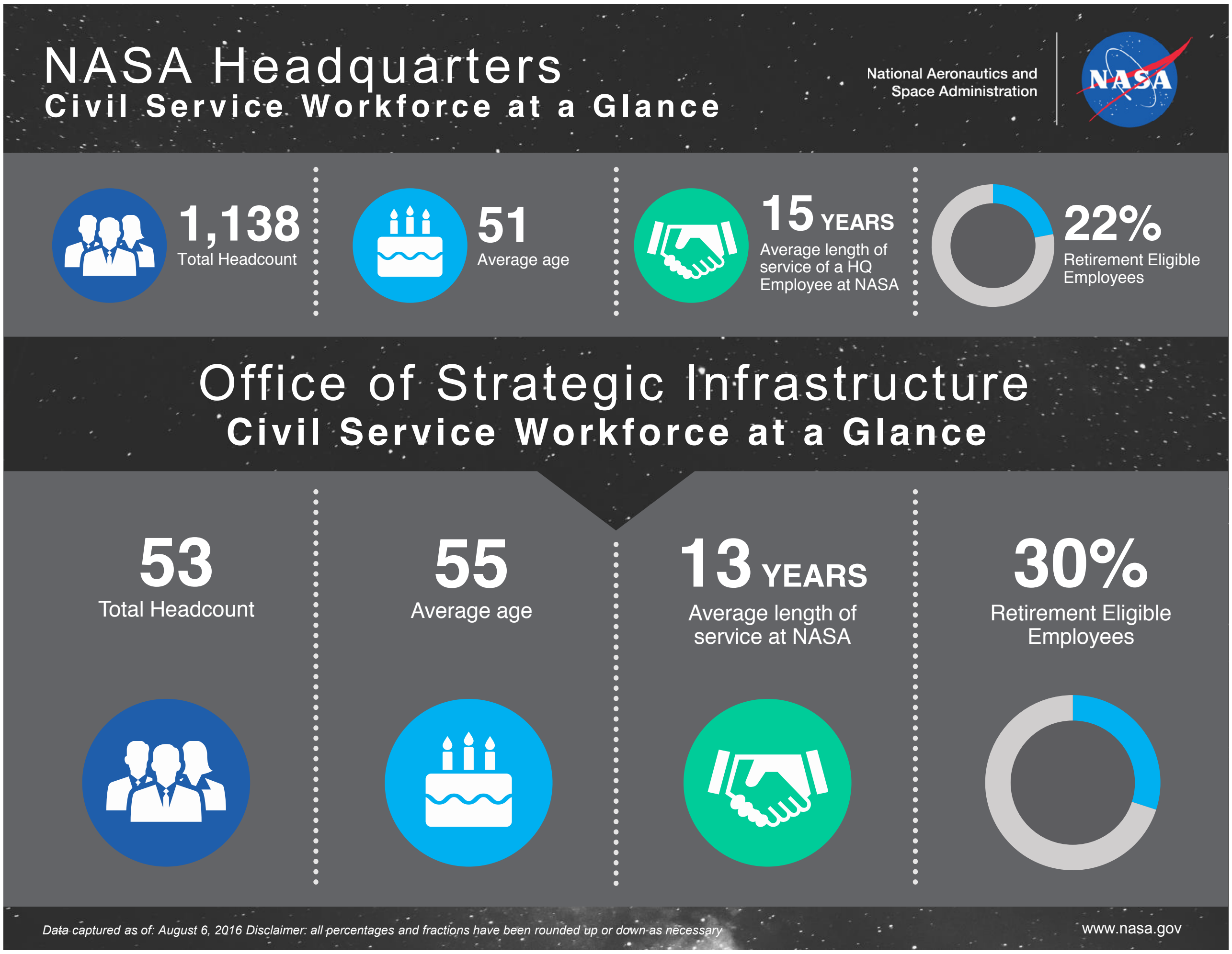


Figure 25.1 Office of Strategic Infrastructure Workforce at a Glance

IMAGE 25.3

SUSTAINABILITY

OSI leads the Agency in the implementation, tracking, and reporting of sustainable practices for energy intensity, water intensity; fleet petroleum use, greenhouse gas pollution, green building practices, and, renewable energy use as defined by signed Executive Order (EO) 13693. NASA has made significant progress in meeting many of the stated goals including water intensity reductions and fleet petroleum use.

FACILITIES BUSINESS SERVICE ASSESSMENT (BSA)

Through the execution of the Business Services Assessment (BSA), NASA is defining the health of each business service area; identifying opportunities for optimization; and developing risk-informed recommendations to establish a more efficient operating model that maintains a minimum set of capabilities and meets current and future mission needs. The Facilities BSA identified opportunities to enable NASA to more effectively and strategically integrate, manage, optimize, and operate the physical infrastructure required to meet the Agency's Mission. OSI is developing the implementation plans for the accepted recommendations.

REDUCE THE FOOTPRINT (RTF)

NASA and other agencies are required to dispose of surplus properties, make more efficient use of the Government's real property assets, and reduce the total square footage of their domestic owned building inventory, with emphasis on offices and warehouses, relative to an established baseline. When NASA Centers seek to acquire or construct new facilities, they are required to meet the RTF goals by eliminating more square footage than they add. As Centers update their facility master plans, they must identify potential consolidation and disposals of unneeded assets.

ENVIRONMENTAL CLEAN-UP OF SANTA SUSANA FIELD LABORATORY (SSFL)

In 2010 The Department of Energy (DOE) and NASA signed Administrative Orders on Consent (AOC) with the California Environmental Protection Agency that defined the process for the characterization and cleanup end-state of water and soil of the SSFL. Soils determined to be contaminated over background levels must be removed from the site and backfilled with clean soils by the end of 2017. Actual soil removal will start once the AOC completes its identification of background cleanup levels and the State of California: 1) completes identification of background cleanup levels; 2) completes its California Environmental Quality Act (CEQA) documentation, and 3) approves the NASA Soils Remedial Action Implementation Plan. Demolition is currently being conducted.

! ADDITIONAL RESOURCES

[Strategic Sustainability Performance Plan (SSPP)]

OFFICE OF COMMUNICATIONS (OCOMM)

MISSION STATEMENT

The Office of Communications (OCOMM) serves as NASA's corporate communications function, accountable for managing the Agency's communications activities, events, and products for stakeholders and the public. OCOMM is responsible for planning, coordinating, and directing Agency-wide communications efforts regarding all facets of NASA's mission, programs, activities, and functions. The scope of the Agency's communications function entails a diverse and integrated set of efforts including news and media engagement, digital services and products (including web, multimedia, and social media), internal communications, non-technical publications, exhibits, as well as speaking and public engagement activities and events. OCOMM provides for the widest practicable and appropriate dissemination of information to news and media organizations, employees, key stakeholders, and the public regarding NASA's mission, work, and accomplishments. OCOMM promotes effective communications by ensuring synergy and strategic focus, working collaboratively with the Office of Education, Office of Legislative and Intergovernmental Affairs, Mission Directorates, Centers, and other organizations as appropriate.

OFFICE WEBSITE - *http://www.nasa.gov/news/index.html*

IMAGE 26.1

OFFICE OF COMMUNICATIONS CORE FUNCTIONS

COMMUNICATIONS COORDINATING COUNCIL (CCC)

Decision-making body for strategic direction, planning, and implementation of NASA's communications efforts. Comprised of the most senior leaders accountable for conducting communications functions within their organizations, including Mission Directorates, Centers, and HQ functional offices.

STRATEGY AND INTEGRATION

Accountable for planning and orchestrating strategic communications processes and activities. Scope includes managing the CCC and its operations, driving a forward-looking strategic communications planning and implementation process, executing a metrics program, and building strategic partnerships and alliances to magnify NASA's capacity to reach, engage, and educate the public.

NEWS AND MEDIA ENGAGEMENT

Accountable for planning, developing, and implementing news and media engagement activities. Scope includes the production and distribution of news products to the media and public, including release of videos, images, and other products.

PUBLIC AND STAKEHOLDER ENGAGEMENT

Accountable for planning and executing events and programs and developing products dedicated to reaching and engaging the public. Scope includes managing the speakers bureau program, managing the Agency programs for exhibits and artifacts, Agency events planning and implementation, as well as guest operations.

HISTORY

Accountable for management and development of historical resources and products. Scope includes research and publications, and maintaining NASA's uniquely rich historical reference collection used by researchers around the world.

PUBLIC SERVICES

Accountable for planning, organizing, directing, and coordinating the Agency FOIA program. Scope also includes operation of the public inquiries function.

DIGITAL SERVICES

Accountable for planning, developing, and deploying digital products and services in support of all communications activities and in alignment with NASA communications priorities to reach and engage a significantly large and diverse set of audiences. Scope includes overall policy guidance and direction for content and operation of NASA TV, management of multimedia content including videos and images, production and operations of www.nasa.gov, and NASA's social media presence.

IMAGE 26.2

OFFICE OF COMMUNICATIONS ORGANIZATION

OCOMM serves as the corporate, Agency-wide communications function for NASA. The Communications Coordinating Council (CCC), comprised of the Agency's communications leaders representing field centers, mission Directorates, and HQ functional offices, is the strategic governing body for Communications, chaired by the Associate Administrator for Communications. OCOMM in coordination with the CCC, drives a rigorous annual planning process to establish communications priorities and define the communications portfolio of priority activities. The CCC meets monthly to oversee the Agency's communications portfolio.

OCOMM is organized in six divisions to drive a corporate approach, each managing a set of Communications functions Agency-wide. OCOMM maintains key relationships with the Office of Education, OLIA, and Mission Directorates, and Centers to drive strategic efforts.

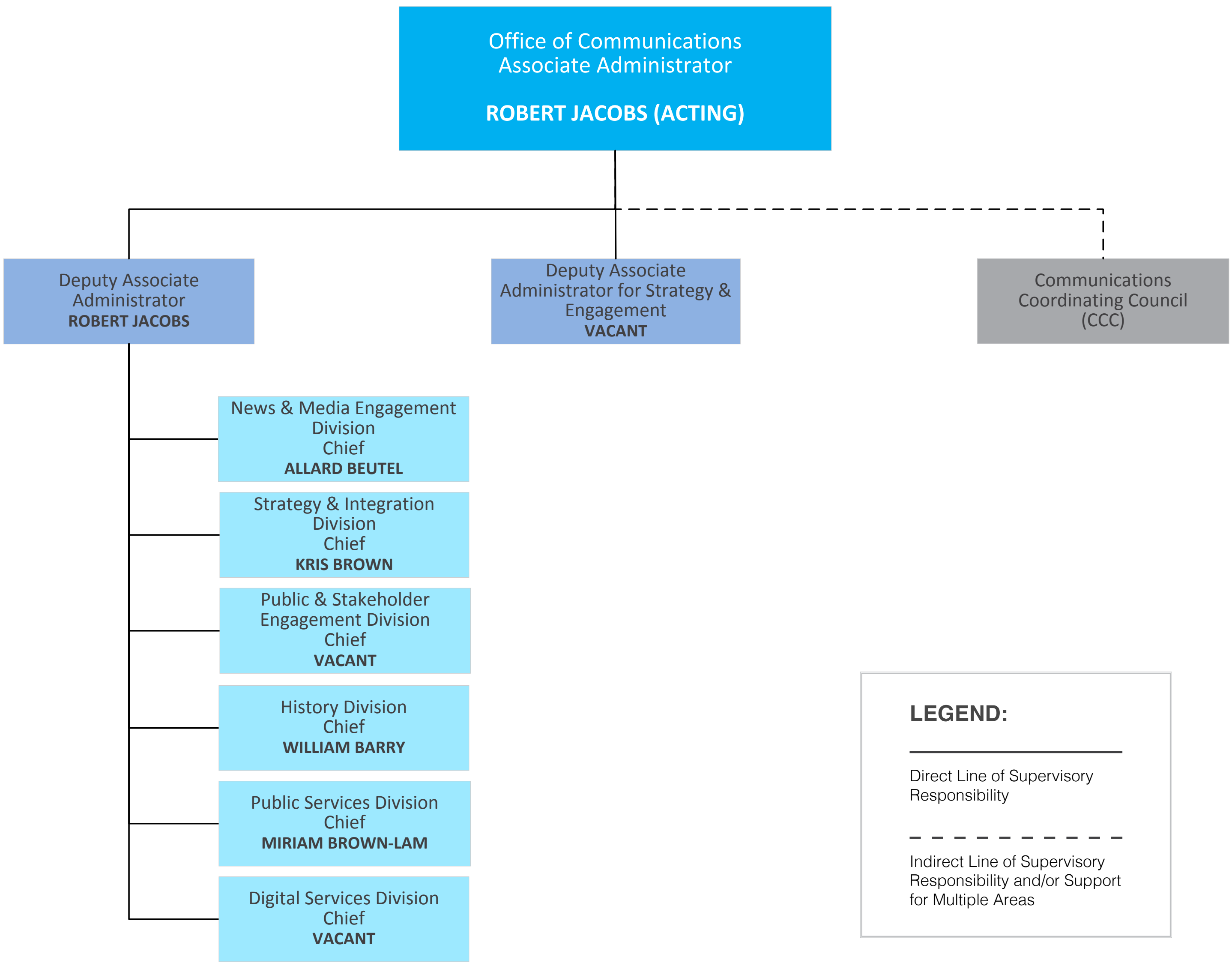


Figure 26.1 Office of Communications (OCOMM) Organization Chart

ASSOCIATE ADMINISTRATOR
VACANT

DEPUTY ASSOCIATE ADMINISTRATOR
MR. ROBERT (BOB) JACOBS

Mr. Bob Jacobs is a senior NASA spokesperson and serves as the Deputy Assistant Administrator for the Office of Communications. He is responsible for leading and executing many of the Agency's public communications activities. Jacobs's has an extensive background in leadership, organizational change, and crisis communications. An Emmy-award winning journalist and strategic communicator, he has championed the use of emerging technologies to better engage the public. He launched and moderates many of the Agency's social media initiatives, and is responsible for the Agency's primary homepage and NASA TV. A published author and editor of several books, his work has been honored with four NASA medals for exceptional service and outstanding leadership, as well as a 2015 Presidential Rank Award.

IMAGE 26.3

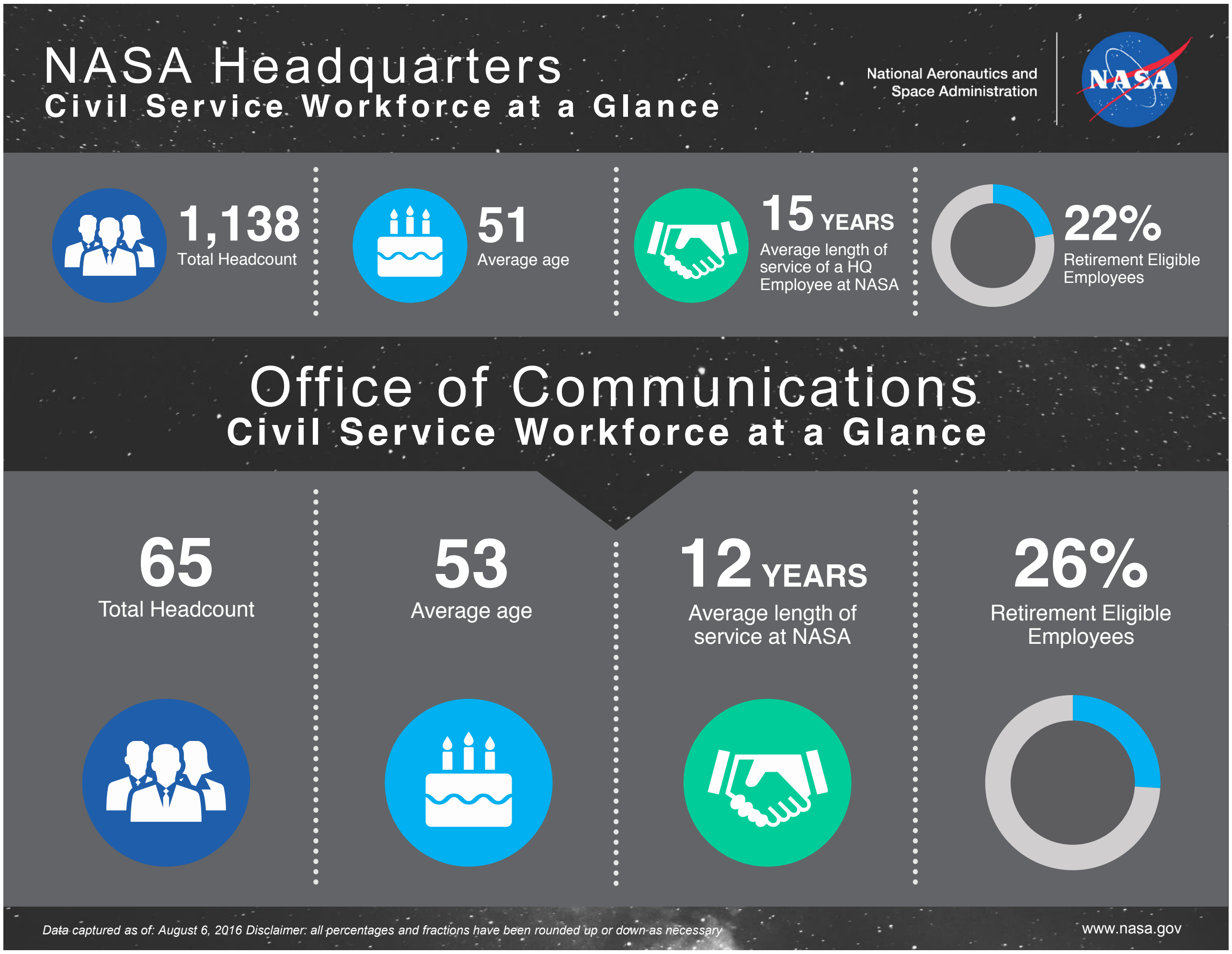


Figure 26.2 Office of Communications Workforce at a Glance

IMAGE 26.4

STRATEGIC COMMUNICATIONS PLANNING AND IMPLEMENTATION

Over the past three years, OCOMM, with the active engagement of the CCC, has undergone an extensive strategic communications planning and implementation initiative. This began with substantive changes in polices and governance, and has involved extensive changes in process and approach. This initiative has fundamentally changed NASA's communications operational model, moving from a distributed and fragmented approach to one that is corporate and strategic. Changes in policy included establishing an overarching policy for communications - NPD 1380.1, and the addition of a requirement for every flight program and project to establish and implement a communications plan. Changes in governance involved the charter of the CCC as a decisional council. Operationally, the CCC established a set of communications priorities, overarching messages, and branding which now frame all Agency communications products and activities. In addition, the OCOMM, in coordination with the CCC, now drives a rigorous annual planning and implementation process to identify and establish priority communications activities in a hierarchy (level 1, 2, and 3 activities) used to define and manage the communications portfolio. The CCC manages planning and implementation of the portfolio, reviews communications plans and strategies for all level 1 and 2 activities, and oversees an Agency-wide, corporate communications strategy. This recently established planning and implementation process provides, for the first time, strategic oversight of the Agency's highly-distributed model for communications and corporate management of hundreds of activities and products, enabling effective management of NASA's brand and ultimately better public understanding of what NASA does and why.

OCOMM REORGANIZATION

OCOMM formulated and implemented a reorganization effective August 7, 2016. The new organization has positioned OCOMM to more effectively lead the strategic communications efforts that have been put into place, provide career development and growth opportunities within the organization, and better facilitate a more corporate, Agency-driven approach to managing the various communications functions within NASA. Coupled with this reorganization, OCOMM has implemented an organizational development effort, working with an outside consultant in moving the new organization forward.

EDUCATION AND OUTREACH BUSINESS SERVICES ASSESSMENT (BSA)

Through the execution of BSAs, NASA is defining the health of each business service area; identifying opportunities for optimization; and developing risk-informed recommendations to establish a more efficient operating model that maintains a minimum set of capabilities and meets current and future mission needs. The Education and Outreach BSA began April 12, 2016 and is ongoing. Dan Woodard is serving as the BSA Core Team co-lead and Kris Brown is serving as the Subject Matter Expert (SME). The BSA core team is presented its findings and recommendations to the Business Services Steering Committee on September 12. The outcomes of the BSA will drive an implementation effort expected to begin in 2016. OCOMM views the BSA as an opportunity to convey the significant progress made in moving to a corporate communications model over the past several years, and outline the vision and plans for further changes.

ADDITIONAL RESOURCES

OCOMM manages the development and operations of the Agency's flagship website and social media platforms

- www [NASA Homepage]
- www [NASA on YouTube]
- www [NASA on Social Media]
- www [NASA Communications Toolkit]

OFFICE OF DIVERSITY AND EQUAL OPPORTUNITY (ODEO)

MISSION STATEMENT

The Office of Diversity and Equal Opportunity (ODEO) is responsible for developing and aligning NASA equal opportunity (EO), civil rights compliance, and diversity strategies, programs, policies, and processes consistent with the Agency's mission, strategic goals, and performance outcomes. The ODEO establishes Agency-wide policies on diversity and EO and defines strategies, program objectives, and top-level requirements; ensures statutory, regulatory, and fiduciary compliance with internal and external EO laws; provides technical assistance, training, and advocacy to promote an open and inclusive workplace; ensures consistency of approach to improve functional performance across the Agency; and monitors diversity and EO program performance.

OFFICE WEBSITE *- http://odeo.hq.nasa.gov/*

IMAGE 27.1

OFFICE OF DIVERSITY AND EQUAL OPPORTUNITY CORE FUNCTIONS

SETS THE AGENCY'S EQUAL OPPORTUNITY POLICY AND STRATEGY

Develop and oversee Agency-wide programs and processes to achieve consistency of approach in eliminating barriers to the recruitment, retention, and promotion of a high-caliber and diverse workforce, particularly in mission-critical occupations and leadership ranks.

MANAGES EQUAL EMPLOYMENT OPPORUNITY (EEO) COMPLAINTS

Administers effective and efficient Agency-wide EEO complaint and Alternative Dispute Resolution (ADR) processes.

LEADS AGENCY DIVERSITY AND INCLUSION INITIATIVES

Defines diversity and inclusion objectives and top-level requirements. Establishes and manages long-term Agency diversity planning and implementation.

AUDITS NASA GRANTEE CIVIL RIGHTS COMPLIANCE

Serves as the focal point for the Agency's internal (federally conducted) and external (NASA grantees) civil rights compliance activities, policies, and procedures, including the development of policies, procedures, and programs to ensure that NASA's grant recipients are provided access to activities in a non-discriminatory manner and administers NASA's civil rights complaint process.

ADVOCATES FOR AN OPEN AND INCLUSIVE WORKPLACE

Provides technical assistance, training, and advocacy to promote an open and inclusive workplace, ensuring fair and equitable decision making in all aspects of workforce activity, voluntary compliance, and effective and open communication.

OFFICE OF DIVERSITY AND EQUAL OPPORTUNITY ORGANIZATION

The ODEO is comprised of the Office of the Associate Administrator and two divisions with distinct roles: the Program Planning and Evaluation (PPE) Division and the Complaints Management Division (CMD). The Office of the Associate Administrator provides executive leadership and oversight for the effective management of all programs, resources, Agency-wide initiatives, and external requirements. The ODEO has unique requirements relating to the administration of federal civil rights laws pertaining to employees and NASA grantees. PPE manages and directs a wide range of EEO requirements relating to the workforce and EO requirements relating to grantees. CMD manages and implements Agency-wide policies and systems for processing, adjudicating, and resolving individual and class discrimination complaints.

The organizational chart provides insight into the official roles and relationships within ODEO.

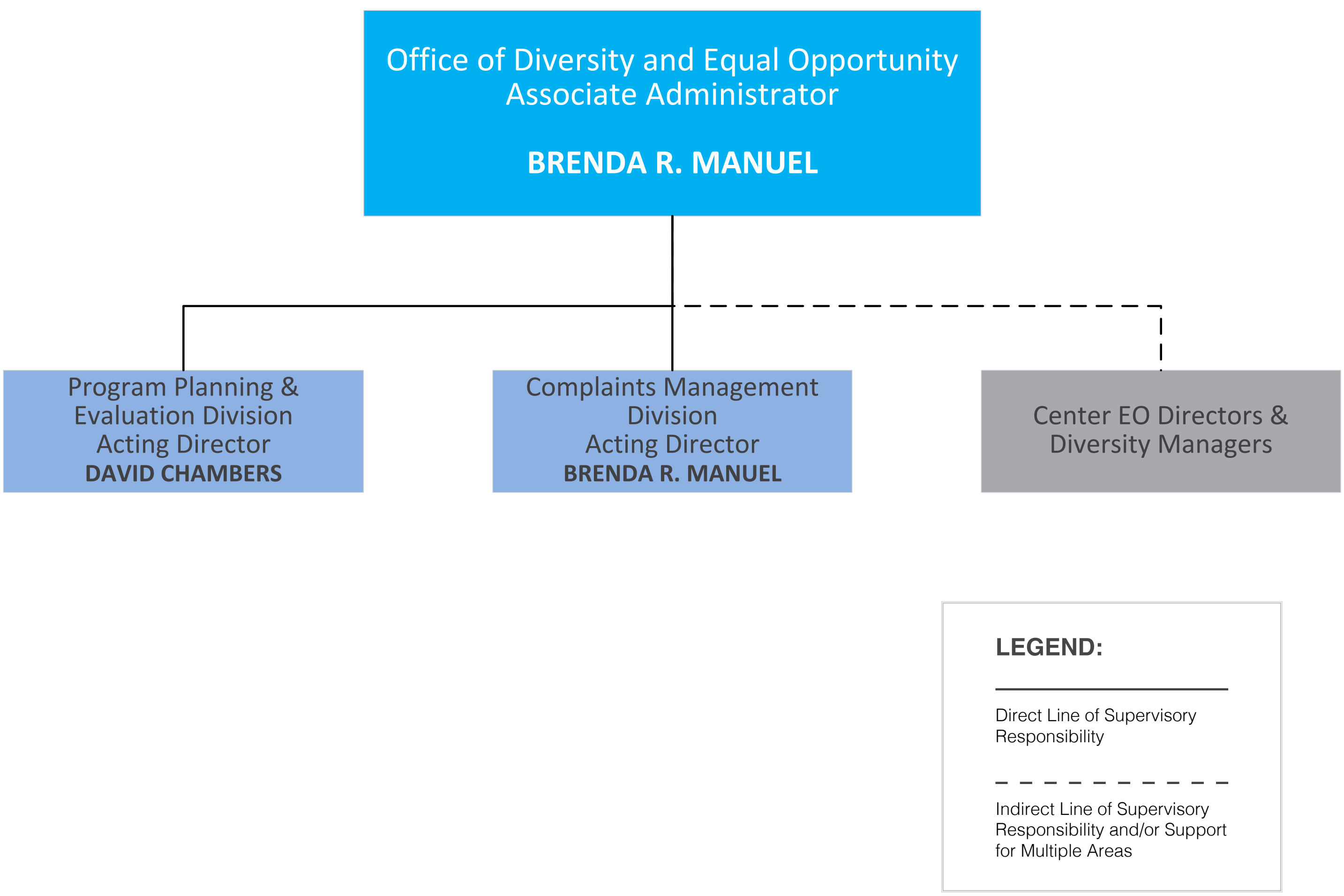


Figure 27.1 Office of Diversity and Equal Opportunity (ODEO) Organization Chart

ASSOCIATE ADMINISTRATOR

MS. BRENDA R. MANUEL

Brenda R. Manuel is the Associate Administrator for Diversity and Equal Opportunity, appointed to this position in October 2006. In this capacity, she serves as the principal advisor to the NASA Administrator on diversity and equal opportunity (EO), establishes overall policy and strategic direction for NASA EO and diversity, defines strategies, program objectives, and top-level requirements, as well as oversees critical Agency programs and processes, including the Agency discrimination complaints process, Alternative Dispute Resolution (ADR) for EEO complaints, civil rights compliance among NASA grant recipient institutions, and diversity and inclusion policy and programs.

EXTENDED BIO - *http://www.nasa.gov/about/highlights/manuel_bio.html*

DIRECTOR, PROGRAM PLANNING AND EVALUATION DIVISION (ACTING)

MR. DAVID CHAMBERS

David Chambers is an equal opportunity (EO) professional with over 20 years of experience in the field. This includes serving for four years as a Civil Rights Analyst with the U.S. Commission on Civil Rights, where he developed policy recommendations for the President and Congress on federal civil rights statutory enforcement. He has been with NASA since 2000 and currently serves as a Senior Civil Rights Analyst in the Agency's Office of Diversity and Equal Opportunity. Among his wide-ranging portfolio of EO roles and responsibilities, he serves as the External (Grantee) Civil Rights Team Lead, the Agency Anti-Harassment Coordinator, and the Executive Secretary of the NASA Diversity and Inclusion Strategic Partnership (DISP).

DIRECTOR, COMPLAINTS MANAGEMENT DIVISION (ACTING)

MS. BRENDA R. MANUEL

Ms. Brenda Manuel, the Associate Administrator for Diversity and Equal Opportunity, is also currently acting as Director for Complaints Management while this division position is vacant.

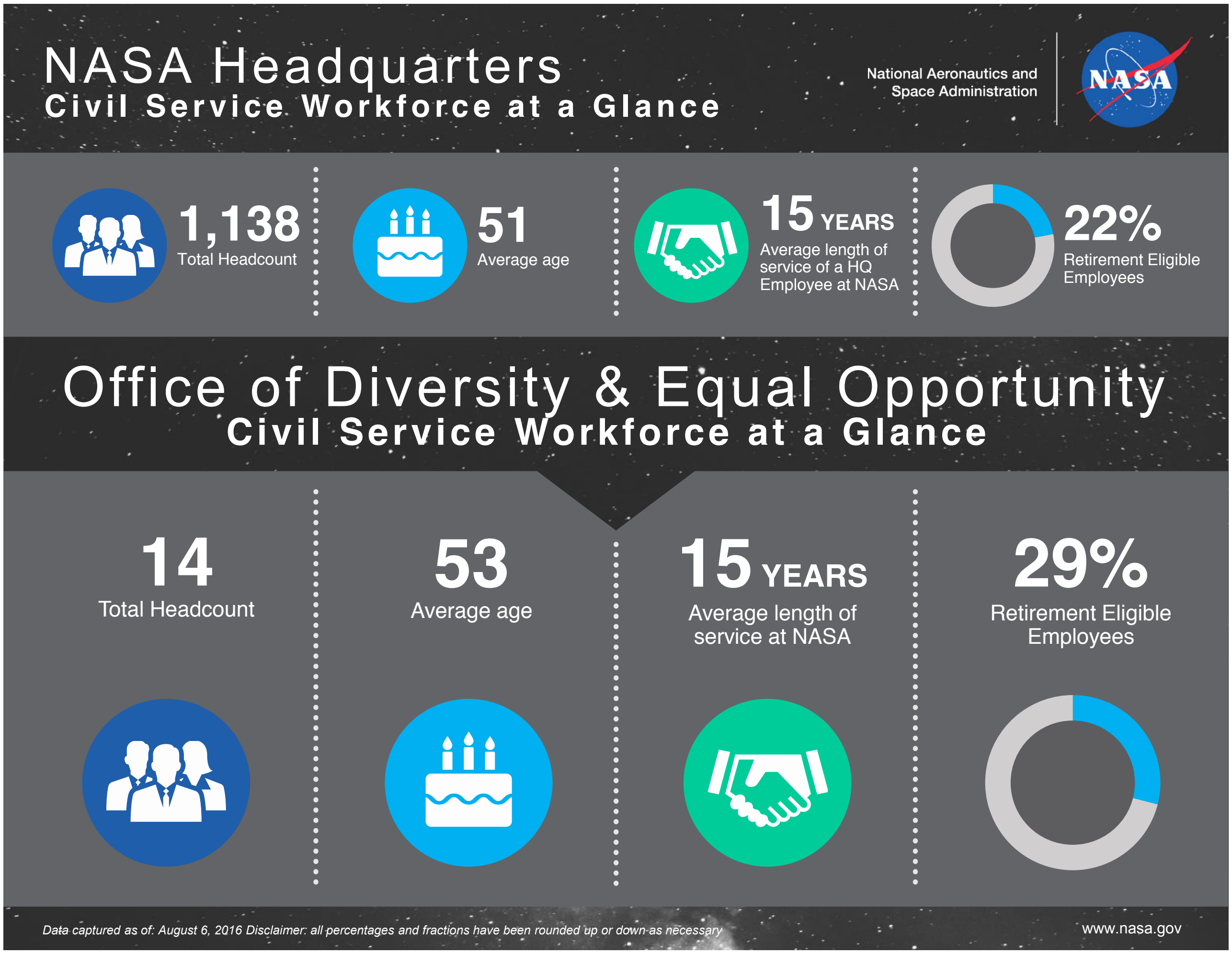


Figure 27.2 Office of Diversity and Equal Opportunity Workforce at a Glance

IMAGE 27.2

MANAGEMENT DIRECTIVE (MD)-715 PROGRAM

NASA shifted to a new framework for this program in 2014. Under U.S. Equal Employment Opportunity Commission (EEOC) Management Directive (MD) 715, federal agencies must submit an annual plan and report identifying and establishing actions to address barriers to EEO within the Agency. Under the new framework, NASA is focusing on a limited number of high-priority challenges while leaving to the Centers how best to define the tactical actions they will use to address the challenges. The biggest challenges now are diversifying the top echelons of the Agency with respect to women and racial minorities and all levels with respect to people with disabilities. The Agency is addressing this through a combination of proactive equal opportunity programs, a comprehensive diversity and inclusion initiative including enhanced efforts to diversify selection panels and applicant pools, and increased focus on shared accountability (see Diversity and Inclusion Program).

DIVERSITY AND INCLUSION (D&I) PROGRAM

NASA established a D&I framework in 2010. The framework encompasses a D&I Strategic Plan (Agency and Center levels), frequent D&I assessment surveys to track employee perceptions and progress, and a D&I Strategic Partnership (DISP), which is a formally chartered senior leadership body that advises the Administrator. Key diversity and inclusion challenges include attracting and advancing a more diverse NASA workforce. On attracting diversity, strategic actions include greater diversity on selection panels and executive participation in outreach and recruitment events involving diverse groups. On advancing the current workforce, NASA added a second level review requirement to make sure performance ratings are more consistent and well-justified. Senior leaders were directed to continue Agency initiatives focused on supervision as a discipline, with an emphasis on culture and shared accountability and an emphasis on continued process improvement by utilizing survey data to identify troubled organizations and design improvement plans.

EXTERNAL (GRANTEE) COMPLIANCE PROGRAM

NASA has a robust compliance program in place for assessing civil rights compliance of its grantee institutions. In conducting these assessments, NASA addresses both unintentional adverse impacts, such as implicit bias in policies and practices, as well as deliberate denials of equal opportunity, such as discriminatory harassment. Through the Agency's Mission STEM website and related technical assistance, including workshops with grantees, NASA seeks to address ongoing challenges, such as sexual harassment in the sciences. Compliance review reports with findings and recommendations to address compliance issues, public statements from NASA senior leadership disseminated widely, and ongoing technical assistance to grantees are key mechanisms through which the Agency seeks to address civil rights and D&I challenges in STEM fields.

IMAGE 27.3

COMPLAINTS PROCESSING AND ADJUDICATION

NASA processes EEO complaints in accordance with federal civil rights laws. The use of Alternative Dispute Resolution (ADR) to resolve EEO complaints is mandated by both Equal Opportunity Employment Commission (EEOC) regulation and guidance. The most significant challenge is to establish an Agency-wide commitment to ADR and means to overcome opposition to ADR from both managers and complainants. To address this challenge, NASA is presently preparing to train employees to see ADR as a no-risk means of expressing their concerns and possibly rectifying problems, rather than having to incur the risk and expense of the EEO process. NASA is also reaching out to management and complainants to promote ADR as a means to resolve complaints. Interim statistics show a marked improvement in the Agency's ADR offer and participation rates. As these rates improve, there is confidence that the resolution rates will similarly improve as well.

PROACTIVE CONFLICT RESOLUTION PROGRAMS

These programs, including the Anti-Harassment Program (AHP) and the Conflict Management Program (CMP), provide innovative means of addressing workplace conflict issues. The AHP offers an additional avenue of relief for employees to raise allegations of harassing conduct based on a protected basis, e.g., racial, sexual, or to address other inappropriate behavior, such as bullying. Program outcomes include prompt and effective processing of harassment allegations. The CMP helps NASA organizations maintain open and effective lines of communication through modalities such as basic conflict management training, web-based refresher training, team training, and individual conflict consultations. Challenges remain, such as lack of trust between. NASA is addressing the challenges in part through greater collaboration between key stakeholders in the development of relevant policy and continued emphasis on needed education.

! ADDITIONAL RESOURCES

WWW MissionSTEM Website

Mitigating Bias at NASA

OFFICE OF EDUCATION (OE)

MISSION STATEMENT

NASA Education's primary mission is to advance high-quality science, technology, engineering, and mathematics (STEM) education using NASA's unique capabilities. Our education efforts reach learners, educators, and institutions by implementing an integrated education portfolio. NASA's Office of Education (OE) and the education offices at each NASA Center across the country partner strategically with a wide range of entities to achieve mutually beneficial outcomes. Partners include governmental, academic, industrial, entrepreneurial, nonprofit, and international organizations to leverage resources, reach wider and more diverse audiences, and achieve mutually beneficial objectives.

OFFICE WEBSITE *- http://www.nasa.gov/offices/education/about/*

IMAGE 28.1

OFFICE OF EDUCATION CORE FUNCTIONS

EDUCATOR PROFESSIONAL DEVELOPMENT (EPD)
Provide educators with the knowledge, skills, and ability to deliver unique STEM content to learners who will ensure the economic growth and competitiveness of our Nation.

NASA INTERNSHIPS, FELLOWSHIPS, AND SCHOLARSHIPS (NIFS)
Enhance and increase the capability, diversity, and size of the Nation's future STEM workforce.

INSTITUTIONAL ENGAGEMENT
Increases STEM capabilities at formal and informal educational institutions and organizations by incorporating content based on NASA's missions.

STRATEGIC PARTNERSHIPS
Identify and engage in strategic partnerships (with a focus on national and Agency goals) to share NASA content and expand the reach of select education activities with a documented record of success.

BUILD EDUCATION REQUIREMENTS INTO NASA MISSIONS
Collaborate with Mission Directorates and Programs to create meaningful education plans within Agency space flight programs and projects.

STEM ENGAGEMENT (SE)
Provide opportunities for participatory and experiential learning activities that connect learners to NASA-unique resources.

OFFICE OF EDUCATION ORGANIZATION

The Office of Education (OE) implements a strategically integrated education portfolio, which consists of two programs and four underlying projects. The Aerospace Research and Career Development (ARCD) Program includes the National Space Grant College and Fellowship Program (Space Grant) and the Experimental Program to Stimulate Competitive Research (EPSCoR). The STEM Education and Accountability (SEA) Program includes STEM Education and Accountability Projects (SEAP) and the Minority University Research and Education Project (MUREP). These four projects (Space Grant, EPSCoR, SEAP, and MUREP) align their activities in accordance with the NASA Education lines of business. The four lines of business are STEM Engagement (SE), Educator Professional Development (EPD), NASA Internships, Fellowships, and Scholarships (NIFS), and Institutional Engagement (IE). Space Grant, SEAP, and MUREP invest funds in all four lines of business, while EPSCoR focuses solely on Institutional Engagement. The organizational chart provides insight into the official roles and relationships within OE.

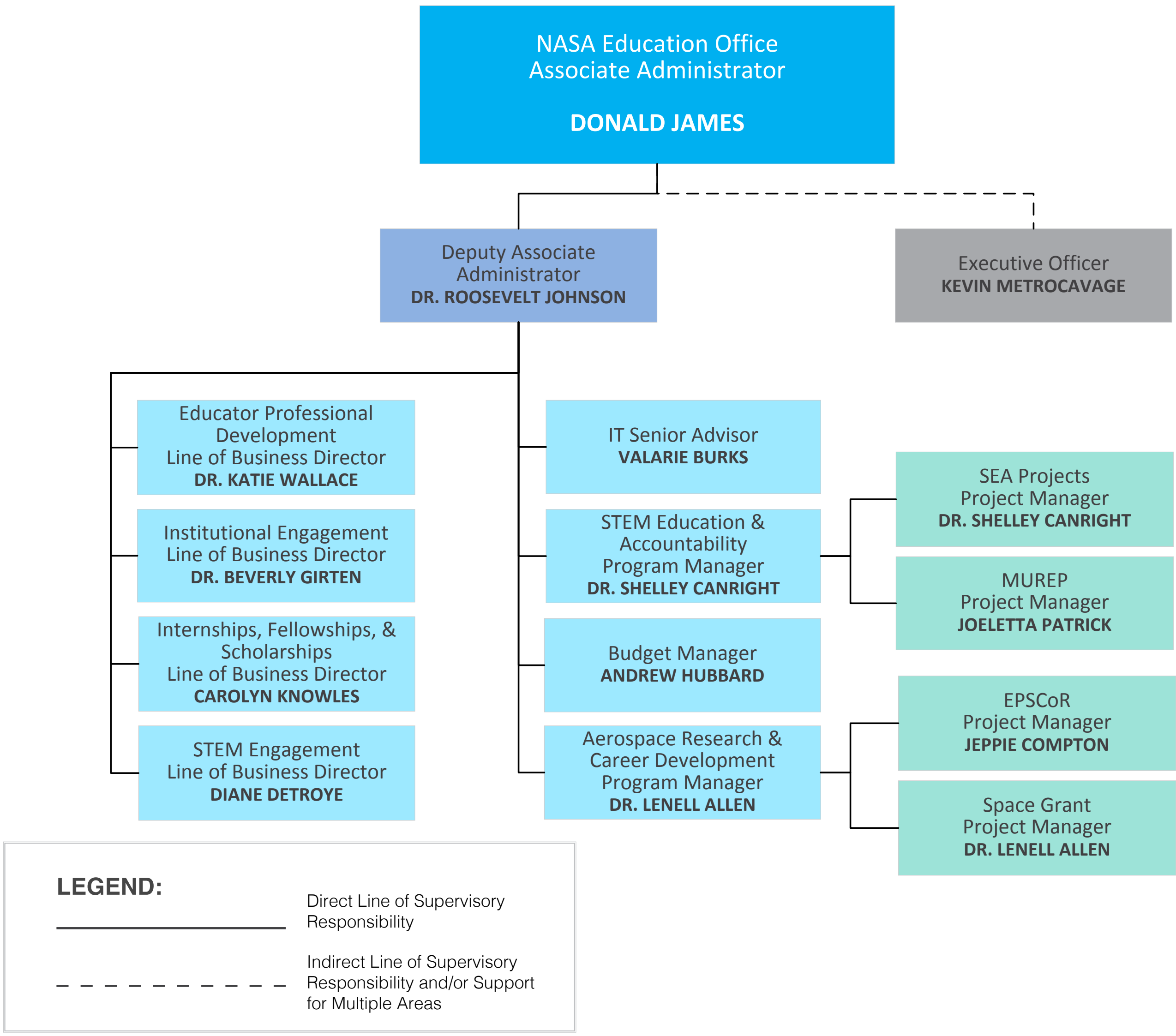


Figure 28.1 Office of Education (OE) Organization Chart

ASSOCIATE ADMINISTRATOR
MR. DONALD JAMES

Donald James is responsible for developing and implementing education programs that strengthen student involvement and public awareness about NASA's scientific goals and missions. He leads the Agency in inspiring interest in STEM through NASA's unique mission, workforce, facilities, research, and innovations. Prior to his appointment, James was Director of the Strategic Communications and Education Directorate at NASA's Ames Research Center. In this capacity, he oversaw operations of all communications, education, and public outreach functions for the Center and supported initiatives to engage a variety of internal and external audiences. During more than 30 years at NASA, he has served in numerous capacities, including public affairs, human capital management, and strategic communications.

EXTENDED BIO - *http://www.nasa.gov/offices/education/leadership/d_James_bio.html#.VBIJgfldU1I*

DEPUTY ASSOCIATE ADMINISTRATOR
DR. ROOSEVELT JOHNSON

Dr. Roosevelt Y. Johnson, Deputy Associate Administrator for Education, is a member of the senior management team responsible for the development and implementation of NASA's education programs to strengthen involvement and public awareness about the Agency's scientific goals and missions. Johnson has been a champion and leader of groundbreaking efforts to broaden participation in STEM disciplines. Prior to NASA, he served more than 20 years as a program director for the National Science Foundation, working to increase the participation and advancement of underrepresented minorities, women and girls, persons with disabilities, and minority-serving institutions in science and engineering disciplines, as well as promoting innovative STEM education program development at a national level.

EXTENDED BIO - *http://www.nasa.gov/offices/education/leadership/johnson_bio.html*

IMAGE 28.2

OFFICE OF EDUCATION AT A GLANCE

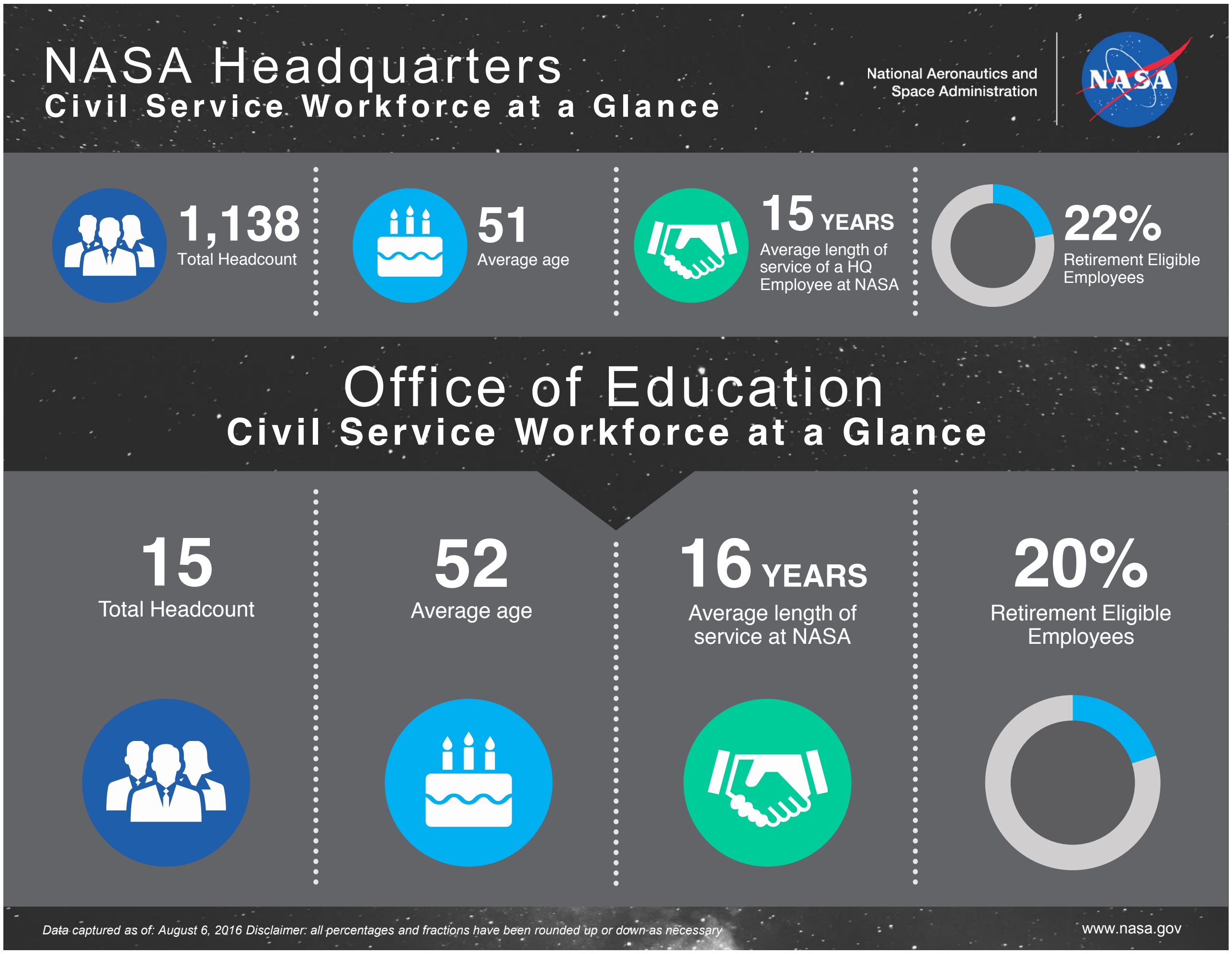


Figure 28.2 Office of Education Workforce at a Glance

IMAGE 28.3

BUSINESS SERVICE ASSESSMENT (BSA) FOR THE OFFICE OF EDUCATION

Through the execution of the Business Services Assessment (BSA), NASA is defining the health of each business service area; identifying opportunities for optimization; and developing risk-informed recommendations to establish a more efficient operating model that maintains a minimum set of capabilities and meets current and future mission needs. OE is participating in a BSA with the following two goals: 1) assess current Agency capability to (a) enable NASA to advance high-quality STEM education using NASA's unique capabilities, and (b) inspire, inform, and engage the public to promote interest and participation in NASA's mission; and 2) evaluate the health of the Agency's current education and outreach functions, identify opportunities for optimization, greater collaboration, and integration, and provide findings that will promote excellence, consistency, and efficiency across the Agency. Anticipated outcomes include, but are not limited to, identifying areas in which Education and HQ office outreach functions and activities can strategically be linked to reflect an integrated Agency-wide approach and portfolio, and the development of governance structures that strategically and efficiently make the best use of the Agency resources for education and outreach activities. Initial data collection is mostly complete, and the BSA team is currently in the data analysis phase.

EDUCATION COORDINATING COUNCIL (ECC)

Established in 2012, the ECC serves as the Agency's senior decision-making body for strategic direction and planning of NASA's education efforts. The ECC determines NASA's strategic education direction and assesses Agency progress toward achieving NASA Education's mission. The ECC is guided by a Governance Charter, which is reviewed every four years. The ECC Charter applies to NASA Headquarters, NASA Centers, including component Facilities, the Jet Propulsion Laboratory (JPL), and all educational activities funded by these entities. The ECC is responsible for maintaining an integrated Agency education portfolio. ECC membership includes all Education Directors, Mission Directorate Education Leads, representatives from NASA Functional Offices, and senior leaders from the Office of Education. The Office of Education assumes various leadership roles on the Council. The NASA Associate Administrator (AA) for Education serves as the ECC Chair and holds the ultimate decision-making authority for the ECC. Additionally, the AA appoints an Executive Secretary to manage the activities of the ECC. Ongoing responsibilities of the ECC include the performance assessment of all NASA Education programs and projects to ensure an efficient use of Agency resources in support of the achievement of NASA Agency and Education objectives.

IMAGE 28.4

OFFICE OF EDUCATION AGENCY INITIATIVES

FEDERAL STEM EDUCATION COLLABORATIONS

NASA actively contributes to federal-wide efforts to advance collaboration among government agencies to deliver compelling STEM content. In addition to membership on the Committee on STEM Education (CoSTEM), NASA is Co-Chair of the Federal Coordination in STEM Education Task Force (FC-STEM). FC-STEM oversees the implementation of the 5-Year Federal Strategic Plan for STEM Education through five Interagency Working Groups (IWGs) aligned to five priority investment areas of the strategic plan. In addition to active participation in all of the IWGs, NASA is the Co-Chair for the STEM Engagement IWG.

WHITE HOUSE INITIATIVES

NASA consistently provides an active role supporting Presidential initiatives. Most recently, NASA Education joined agencies from across the Federal government by participating in the National Week at the Labs, an initiative driven by the White House Office of Science and Technology Policy, in coordination with the President's My Brother's Keeper (MBK) initiative and the White House Counsel on Women and Girls, designed to bring students from underrepresented and underserved communities into Federal labs for full or half-day STEM education and engagement programming. This initiative was founded to connect young people to mentoring, support networks, and the skills they need to find a good job or go to college and work their way into the middle class.

PERFORMANCE ASSESSMENT

The Office of Education (OE) aims to provide a unified, systematic, and standardized approach to data collection and performance assessment within NASA Education. Objective and verifiable performance metrics, internal and external review processes, valid and reliable data collection instruments, and evaluation studies are used to assess progress and performance across the portfolio, including lines of business, programs, projects, and activities. To effectively monitor educational investments across the Agency, the Office of Education collects and reports performance data on all NASA Education investments. In addition to collecting data on activity outputs, such as counts of participants, the OE is also developing and testing new data collection instruments intended to assess the short-term outcomes of NASA's educational investments.

ADDITIONAL RESOURCES

- www NASA Education Website
- www STEM Education and Accountability Projects (SEAP) Activities
- www Experimental Program to Stimulate Competitive Research
- www National Space Grant Consortium
- www MUREP Representative Projects
- www NASA Museum Alliance

OFFICE OF INTERNATIONAL AND INTERAGENCY RELATIONS (OIIR)

MISSION STATEMENT

The mission of the Office of International and Interagency Relations (OIIR) is to provide executive leadership, strategic direction, policy coordination, and management oversight for: NASA's international relations, partnerships and activities; relations with U.S. Executive Branch offices and partnerships with key U.S. agencies; and NASA federal advisory committees. OIIR serves as the principal staff-level Agency liaison with the National Security Council, the Office of Science and Technology Policy, the Department of State, and the Department of Defense. OIIR also directs NASA's international relations; develops and supports opportunities for cooperation with both current and newly emerging partners; negotiates cooperative and reimbursable agreements with foreign space agencies and other entities; provides management oversight and staff support of NASA federal advisory committees, commissions and panels; and manages the NASA Export Control Program and foreign travel by NASA employees.

OFFICE WEBSITE *- http://oiir.hq.nasa.gov/*

IMAGE 29.1

OFFICE OF INTERNATIONAL AND INTERAGENCY RELATIONS CORE FUNCTIONS

INTERNATIONAL AND INTERAGENCY RELATIONS

Directs NASA's international relations through the development, coordination, and implementation of Agency international policies and the development, coordination, and negotiations of NASA international agreements. Serves as the principal advisor to the Office of the Administrator and provides consultation to NASA officials on matters involving international and interagency relations.

TRAVEL, VISITOR, AND EXPORT CONTROLS

Serves as the focal point for Agency-wide Export Control Program and J-1 Visitor program, and oversees NASA's foreign travel policy.

FEDERAL COMMITTEES AND COMMISSIONS LIAISON

Serves as the Agency focal point for federal advisory committees and federal government-wide commissions and advisory activities, ensuring compliance and managing operations.

EXECUTIVE BRANCH AND EXTERNAL ORGANIZATION LIAISON

Serves as the coordinator of Agency-level interaction with U.S. executive branch departments and agencies, ensuring that the implementation of Agency programs is consistent with the U.S. government's domestic and foreign policies, and facilitates NASA participation in selected interagency forums. Disseminates information on foreign aerospace-related developments of programmatic interest to other NASA offices.

OFFICE OF INTERNATIONAL AND INTERAGENCY RELATIONS ORGANIZATION

OIIR is organized into six divisions located in Washington, D.C. with additional international locations in Paris, Tokyo, and Moscow, and a U.S. Department of Defense liaison position in Colorado Springs, CO.
The six divisions are:

- **Human Exploration and Operations Division**
- **Aeronautics and Cross-Agency Support Division**
- **Science Division**
- **Advisory Committee Management Division**
- **Export Control and Interagency Liaison Division**
- **Resources Management Division.**

The organizational chart provides insight into the official roles and relationships within OIIR.

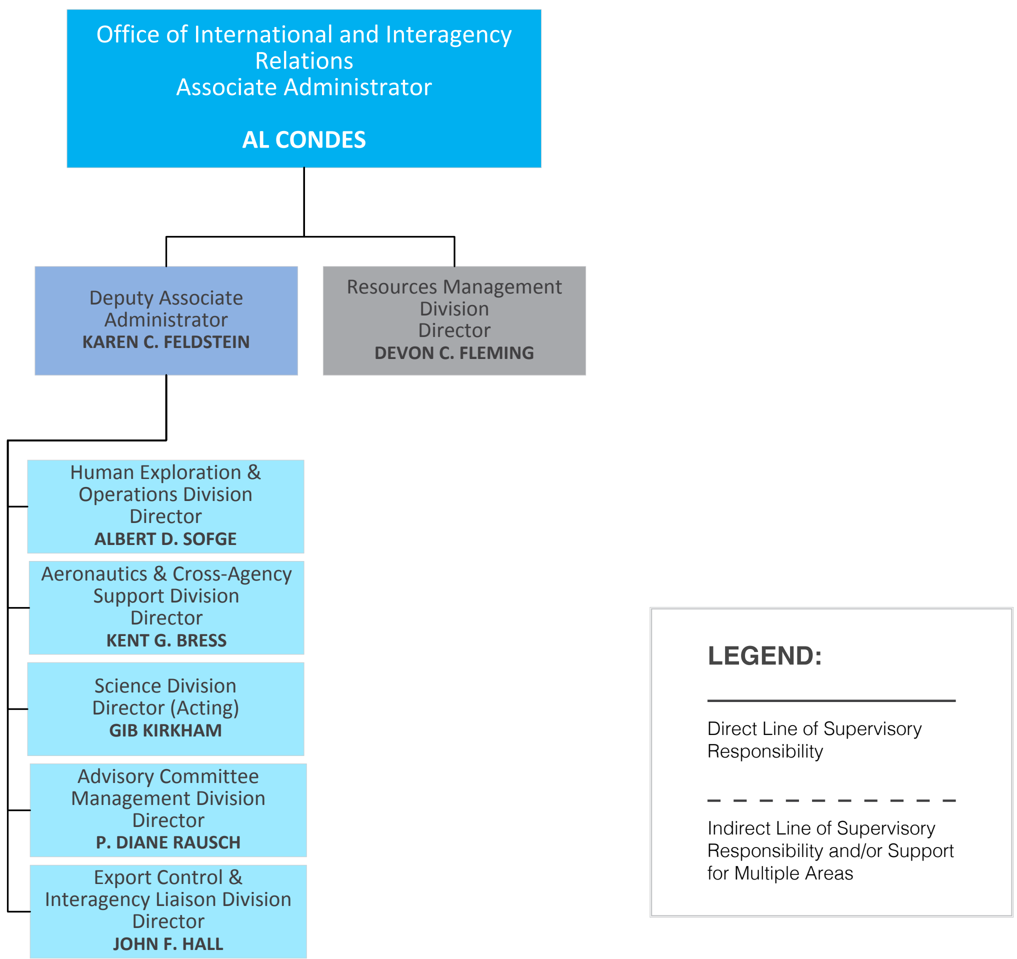


Figure 29.1 Office of International and Interagency Relations (OIIR) Organization Chart

ASSOCIATE ADMINISTRATOR

MR. AL CONDES

Mr. Al Condes is the NASA Associate Administrator for International and Interagency Relations, a position he has held since 2015. He is responsible for executive leadership and management of all aspects of the office including NASA's interaction with executive branch offices and agencies, international relations for NASA's Mission Directorates, administration of NASA's Export Control Program, and support of NASA advisory councils and committees. Mr. Condes began his career at NASA in January 1984 and served in a series of positions with increased responsibility before being selected as the Deputy Assistant Administrator for external relations in 2004. Mr. Condes has a B.A. from George Mason University and an M.A. from George Washington University.
EXTENDED BIO - *http://oiir.hq.nasa.gov/condes.html*

DEPUTY ASSOCIATE ADMINISTRATOR

MS. KAREN C. FELDSTEIN

Ms. Karen Feldstein was selected as the Deputy Associate Administrator for International and Interagency Relations in 2015. She is responsible for supervision and management of all aspects of the office, including NASA's interaction with executive branch offices and agencies, international relations for each of NASA's Mission Directorates, administration of export control and international technology transfer programs, and support of NASA advisory councils and committees. Prior to her current appointment, Ms. Feldstein served in various management and leadership capacities within NASA, and also served as a management consultant prior to joining NASA. Ms. Feldstein completed her undergraduate studies at Tufts University, and earned her M.A. from Johns Hopkins University School of Advanced International Studies (SAIS).
EXTENDED BIO - *http://oiir.hq.nasa.gov/feldstein.html*

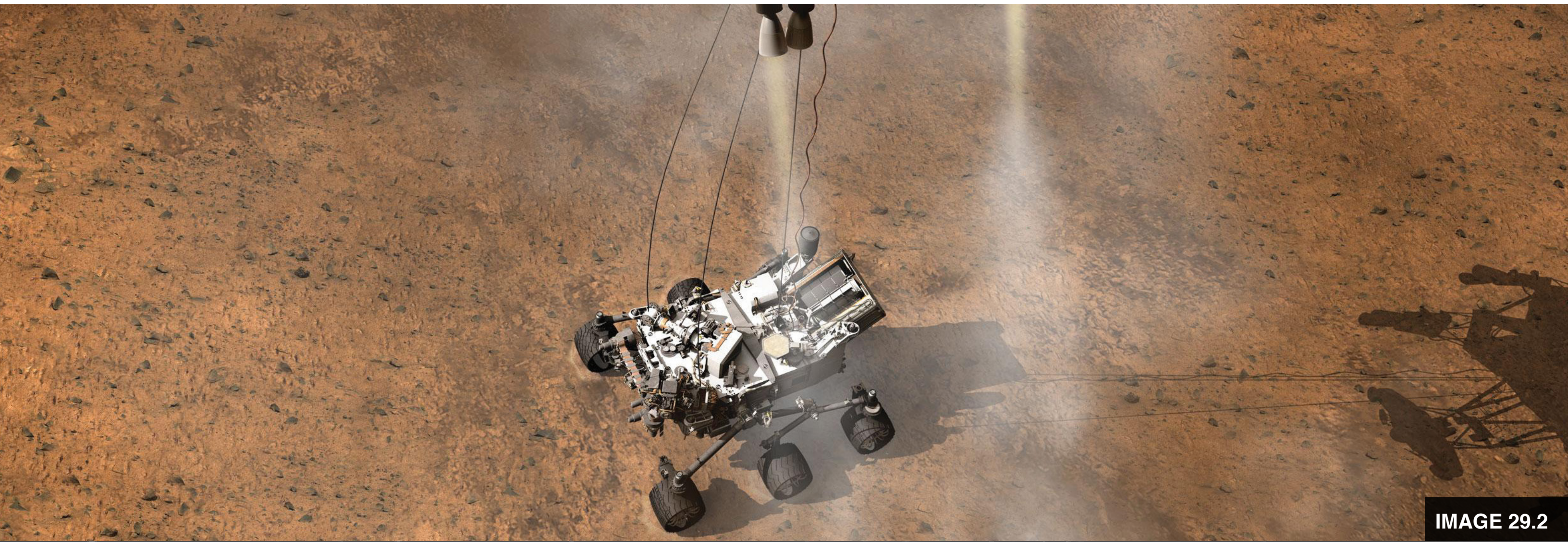


IMAGE 29.2

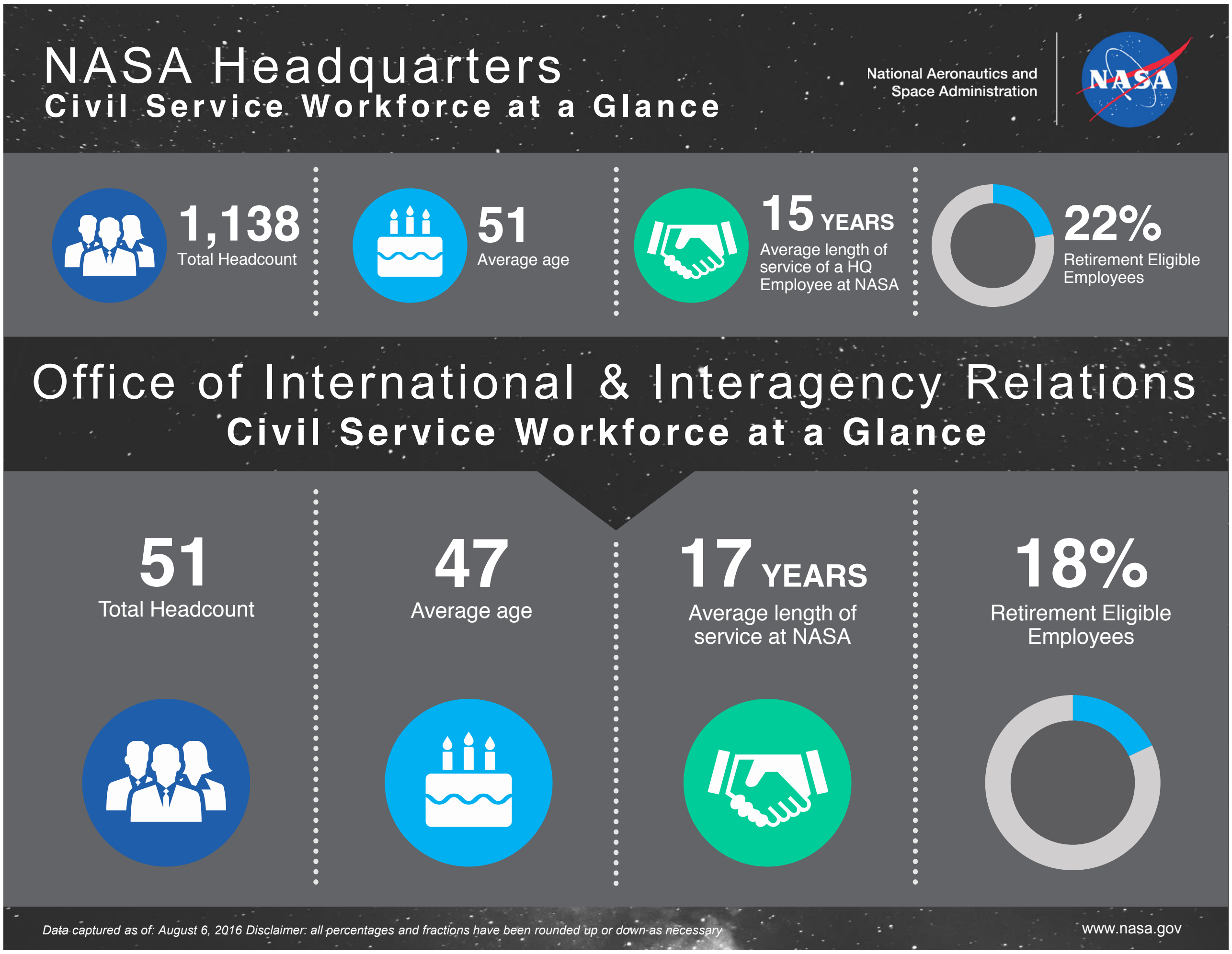


Figure 29.2 Office of International and Interagency Relations Workforce at a Glance

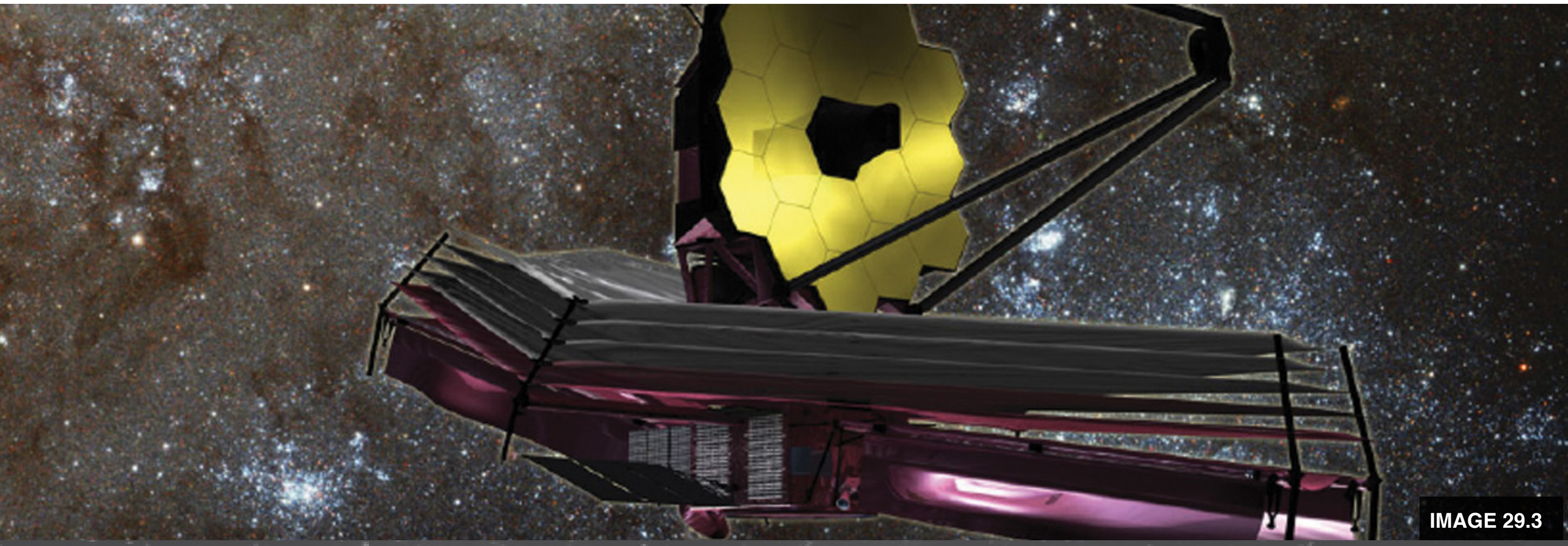


IMAGE 29.3

GLOBAL PARTNERSHIPS

NASA's global partnerships are represented by more than 750 active agreements with over 120 nations. While a few longstanding international partners (e.g., Japan, Russia, Canada, the European Space Agency, and several European nations) have for decades accounted for the vast majority of NASA's international activities, NASA has expanded its global reach in recent years to include cooperative activities with new partners in Asia, Africa, and the Americas. This is a reflection of: 1) growing global interest in the use of Earth science data for societal benefit (i.e., the NASA Soil Moisture Active Passive mission is providing soil moisture information critical to early drought warning, agriculture productivity, weather, disasters, and ecology applications); 2) the vast international nature of current human space flight and space and Earth science activities; and 3) recent growth in international aeronautics collaboration.

TRADITIONAL PARTNERS FOCUS ON EXTENSION OF INTERNATIONAL SPACE STATION AND COORDINATED PLANNING FOR FUTURE HUMAN EXPLORATION

The International Space Station (ISS) partners (Russia, Japan, Canada, and the European Space Agency) will be the core partners for future human exploration beyond low-Earth orbit. NASA is leading discussions among these agencies and other key international partners to develop a shared vision for human exploration in the 2020-2030 timeframe that builds on ISS expertise and lessons learned in support of a human journey to Mars. The completion of this shared vision, the establishment of respective responsibilities associated with its implementation, and senior-level endorsement among the partners have remained key focus areas in 2016. Canada, Russia, and Japan have agreed to extend the ISS program through at least 2024 and indications are favorable for a positive decision by the European Space Agency Council at ministerial level in December 2016 despite intensifying budget pressures.

EMERGING PARTNER: CHINA

NASA's near-term objective with China is to build relationships, understanding, and common standards as the groundwork to enable potential future cooperation in robotic and human exploration. All interactions with Chinese entities are based on the principles of transparency, reciprocity, and mutual benefit and occur in accordance with existing legal and policy constraints. Over the past two years, consistent with congressional requirements, NASA has engaged relevant entities of the government of China to implement bilateral collaboration in five areas: space geodesy; Himalaya glacier characterization; exchange of lunar science mission information; air traffic management; and potential exchange of scientific data from respective carbon monitoring satellite missions. In June 2016, NASA participated in a U.S.-China workshop on orbital debris and collision avoidance. NASA will also participate in the second U.S.-China Civil Space Dialogue in October 2016.

IMAGE 29.4

EMERGING PARTNER: INDIA

Sustained efforts over the last five years to build a productive relationship with the Indian Space Research Organisation (ISRO) have led to significant new cooperation, including: a NASA-ISRO joint Earth science satellite mission; Mars and heliophysics working groups are considering collaboration on current and future missions; a Professional Engineer and Scientist Exchange Program; and airborne Earth science missions in India. India has the potential to be a key contributor in NASA's journey to Mars as it proceeds with experimental technology demonstration activities to support potential development of an indigenous crew transportation capability. NASA has continued to encourage India to consider opportunities for utilizing the ISS and to be a partner in future human and robotic exploration. Discussions with India are continuing at all levels.

NEW ACTIVITIES IN THE MIDDLE EAST, AFRICA, AND ASIA

NASA is developing sustainable partnerships with Israel and the United Arab Emirates (UAE) through a series of high-level visits and the conclusion of new framework agreements for civil space cooperation with both nations. NASA is working with Israel to identify potential cooperative activities on small satellites, nanotechnology, ISS utilization, and Earth observation systems, and with the UAE, cooperation on their planned mission to Mars in 2020. In Africa, NASA is working closely with other U.S. government agencies to multiply the impact of its engagement. NASA and the U.S. Agency for International Development host regional SERVIR hubs in Kenya and Niger, both of which serve 23 member states with plans to expand to nine other nations. NASA has engaged with Korea to capitalize on proven and emerging capabilities, resulting in cooperation in aeronautics, Earth and space science, lunar exploration, space communications, and CubeSats.

ADDITIONAL RESOURCES

- WWW [NASA Policy Directives, Procedures and Guidelines Related to International Activities]
- WWW [Export Control Program Website]

OFFICE OF LEGISLATIVE AND INTERGOVERNMENTAL AFFAIRS (OLIA)

MISSION STATEMENT

The Office of Legislative and Intergovernmental Affairs (OLIA) provides executive leadership, direction, and coordination of communications and relationships related to legislative issues between NASA and the U.S. Congress, state and local governments, domestic space-related associations, and citizen's groups.

OFFICE WEBSITE *- http://www.nasa.gov/offices/olia/home/index.html*

IMAGE 30.1

OFFICE OF LEGISLATIVE AND INTERGOVERNMENTAL AFFAIRS CORE FUNCTIONS

LEGISLATIVE ADVISORY AND ADVOCACY

Principal Advisor to the Office of the Administrator and other NASA officials concerning matters involving relations with the U.S. Congress as well as state and local governments. OLIA advocates for the annual budget request and policy positions on behalf of the Administrator and the President.

AGENCY GOVERNMENT LIAISON

Maintains liaison with Congress, the Executive Office of the President, and other departments and agencies, and state and local government offices on legislative matters.

COORDINATION OF CONGRESSIONAL ACTIONS

Replies to Congressional inquiries and requests, coordinates such replies within NASA and with other agencies as appropriate. Assists Congressional committees of oversight to execute their authority by providing documents and subject matter experts to address their specific requests, including those for hearings and investigations.

LEGISLATIVE POLICY GUIDANCE AND OVERSIGHT

Manages and provides policy guidance and oversight of the Agency's legislative affairs personnel, activities, and operations. In concurrence with Center Directors, manages the Legislative Affairs official at each Center and assesses their performance.

OFFICE OF LEGISLATIVE AND INTERGOVERNMENTAL AFFAIRS ORGANIZATION

OLIA is led by an Associate Administrator and has one Deputy Associate Administrator. The office has three divisions:

1. Legislative Liaison Division, which is the primary liaison to the Members and staff of NASA's House and Senate Authorization Committees, House and Senate leadership offices, as well as the Congressional Budget Office and the Congressional Research Service.
2. Legislative Reference and Analysis Division, which is responsible for monitoring and analyzing legislation of interest to NASA, including Committee markups and monitoring floor activity of key legislation.
3. Outreach Division, which is responsible for legislative outreach with "rank and file" (i.e., no committee or center interest in NASA) members of Congress, members of the House and Senate Committees and Committees on Budget, and with state and local governments.

Each division has its own director.

The organizational chart provides insight into the official roles and relationships within OLIA.

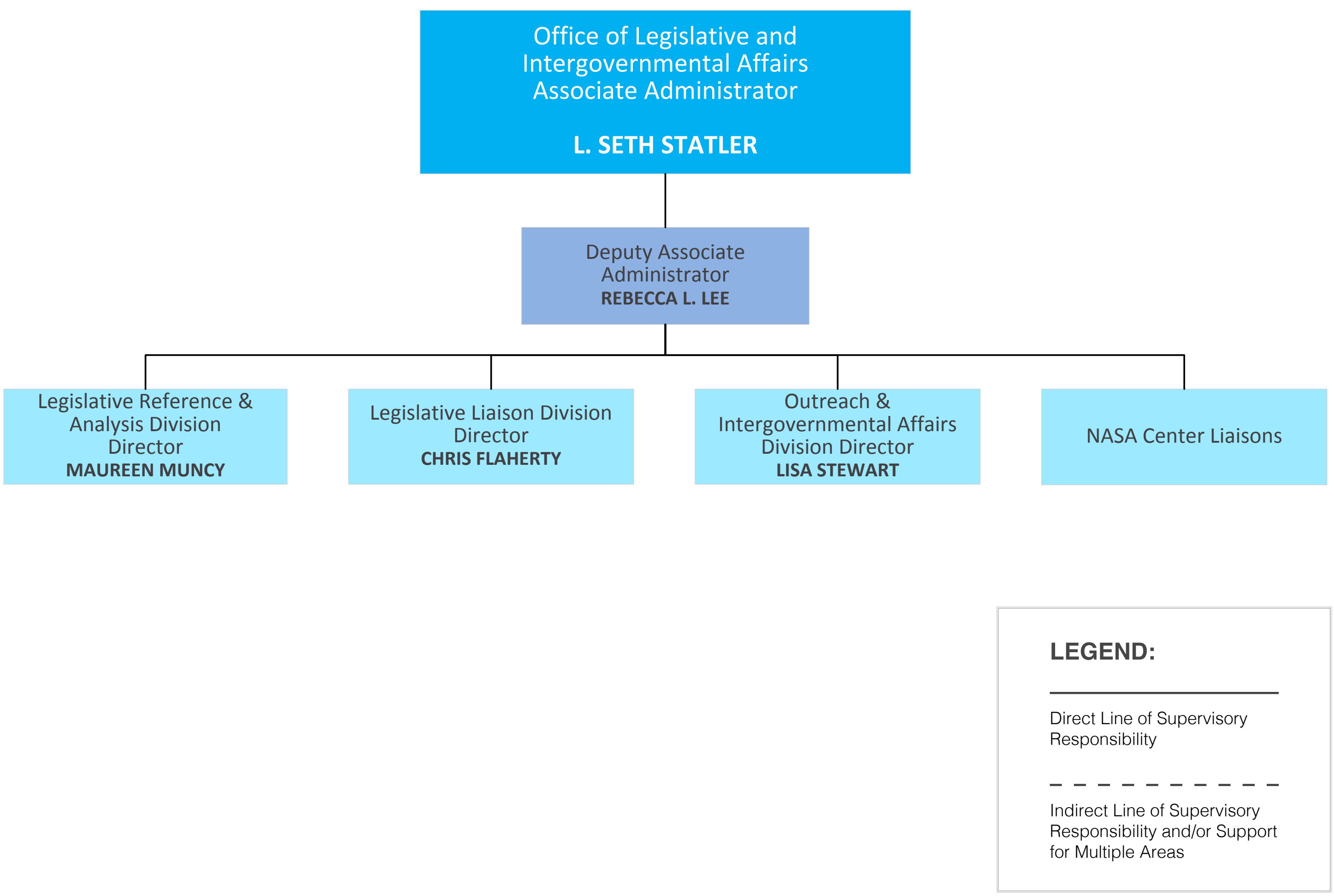


Figure 30.1 Office of Legislative and Intergovernmental Affairs (OLIA) Organization Chart

ASSOCIATE ADMINISTRATOR

MR. L. SETH STATLER

Seth Statler, a civil servant with more than 11 years of career service, was appointed in 2009 to serve as Associate Administrator of OLIA. Statler has served as Deputy Assistant Commissioner for congressional Affairs at Customs and Border Protection (CBP). Statler played a key role in the creation of CBP and Department of Homeland Security (DHS) following 9/11. Statler also managed communications for the Customs Service as a Clinton Administration appointee. Statler previously worked for the House Committee on Appropriations as associate staff for Congressman Steny Hoyer as well as for former Congressman John Sarbanes. Statler earned a BA from Gettysburg College and a MBA from the University of Maryland. He completed the Kennedy School Program for Senior Managers and The Duke Leadership Program. Statler is a director of the National Fallen Firefighters Foundation.

EXTENDED BIO - *http://www.nasa.gov/about/highlights/statler_bio.html*

DEPUTY ASSOCIATE ADMINISTRATOR

MS. REBECCA L. LEE

Ms. Lee has over 10 years of federal government leadership and management experience. From 2012 until 2016, Ms. Lee served as Chief of Staff to the Assistant Director for National Intelligence for Systems and Resource Analyses (SRA) at the Office of the Director of National Intelligence (ODNI). Prior to that, Ms. Lee was the Senior Intelligence Advisor to the USAID Administrator, from 2011 until 2012. From 2007 until 2011, she was the Deputy Chief for Analytic Mission Management at ODNI, where she improved the integration of intelligence analysis across agencies. From 2003 to 2005 Ms. Lee served on the Senate Select Committee on Intelligence, where she conducted oversight of counterterrorism programs and the development of National Counterterrorism Center. Lee earned a Bachelor's degree in International Service and a Master's degree in Peace and Conflict studies from American University.

IMAGE 30.2

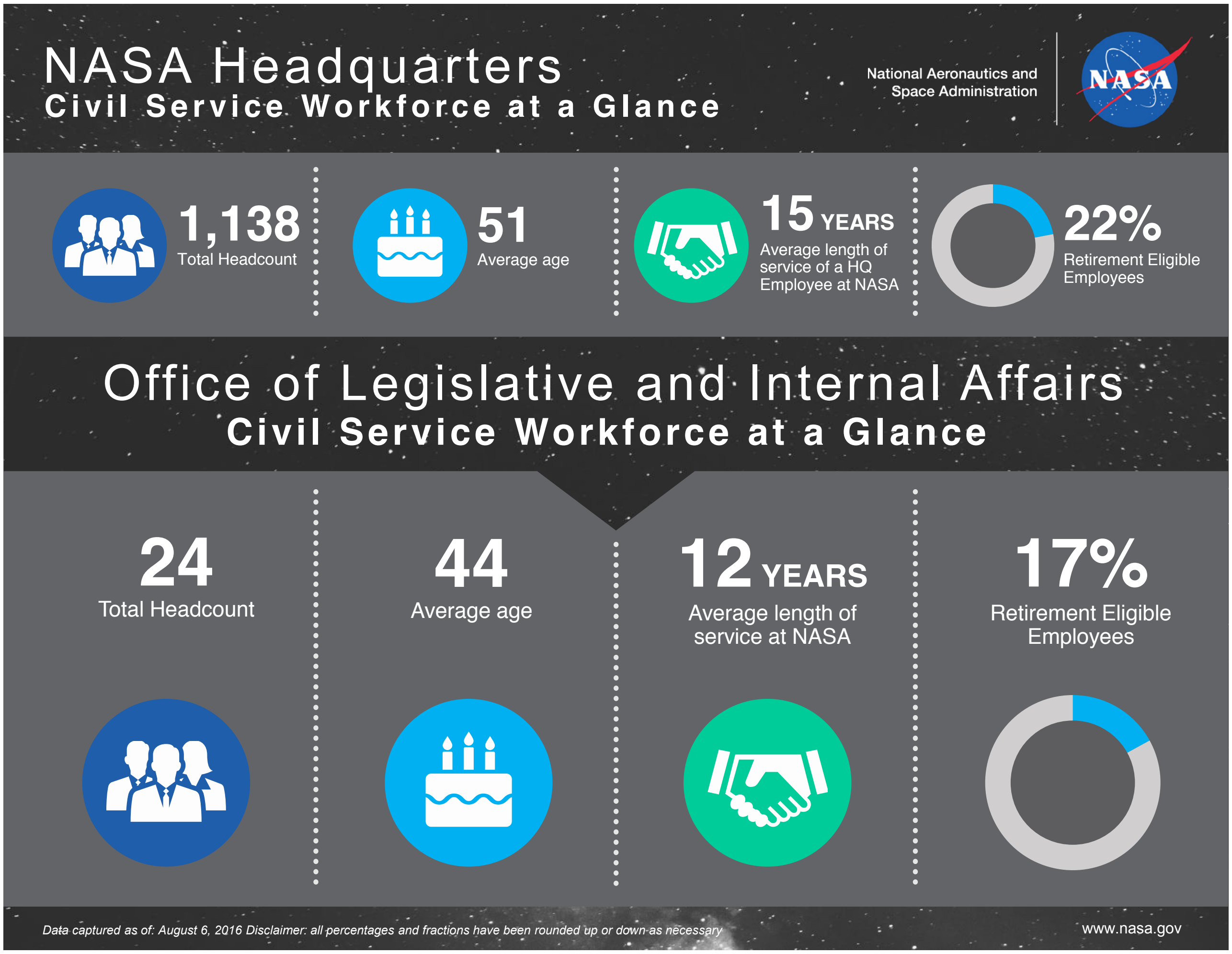


Figure 30.2 Office of Legislative and Intergovernmental Affairs Workforce at a Glance

ADDITIONAL RESOURCES

WWW [Office of Legislative and International Affairs Website]

OFFICE OF SAFETY AND MISSION ASSURANCE (OSMA)

MISSION STATEMENT

The Office of Safety and Mission Assurance (OSMA) provides policy direction, functional oversight, and assessment for all NASA safety, reliability, maintainability, and quality engineering and assurance activities for the Agency. OSMA also serves as the principal advisory resource for the Administrator and other senior officials on matters pertaining to safety and mission success.

OFFICE WEBSITE *- https://sma.nasa.gov/*

IMAGE 31.1

OFFICE OF SAFETY AND MISSION ASSURANCE CORE FUNCTIONS

SAFETY AND MISSION ASSURANCE OVERSIGHT

Provides executive leadership in the development and oversight of Safety and Mission Assurance (SMA) policies and standards in support of NASA's programs, projects, Centers, facilities, and research activities, and through structured application of independent SMA Technical Authority.

SAFETY AND MISSION ASSURANCE DISCIPLINES AND TECHNOLOGIES

Sponsors the innovation and rapid transfer of SMA technologies, processes, and techniques to improve safety and reliability, and reduce the cost of mission success; oversees and assesses the application and technical excellence of SMA tools, knowledge, and practices throughout the program/project lifecycle.

INDEPENDENT REVIEWS

Performs independent SMA assessments, process verification reviews, and critical mission/flight reviews; improves the safety, reliability, and quality of safety-critical and mission-critical software through the NASA Independent Verification and Validation (IV&V) Program.

OFFICE OF SAFETY AND MISSION ASSURANCE ORGANIZATION

The Office of Safety and Mission Assurance (OSMA) is one of three NASA HQ Technical Authority offices (in addition to the Office of the Chief Engineer and the Office of the Chief Health and Medical Officer), and reports to the NASA Administrator. OSMA includes the Safety and Assurance Requirements Division (SARD), the Mission Support Division (MSD), the Resource Management Office (RMO), the NASA Safety Center (NSC) located in Cleveland, Ohio, and the Independent Verification and Validation (IV&V) Program located in Fairmont, West Virginia. The IV&V Program is institutionally managed under the Goddard Space Flight Center in Greenbelt, Maryland.

The organizational chart provides insight into the official roles and relationships within OSMA.

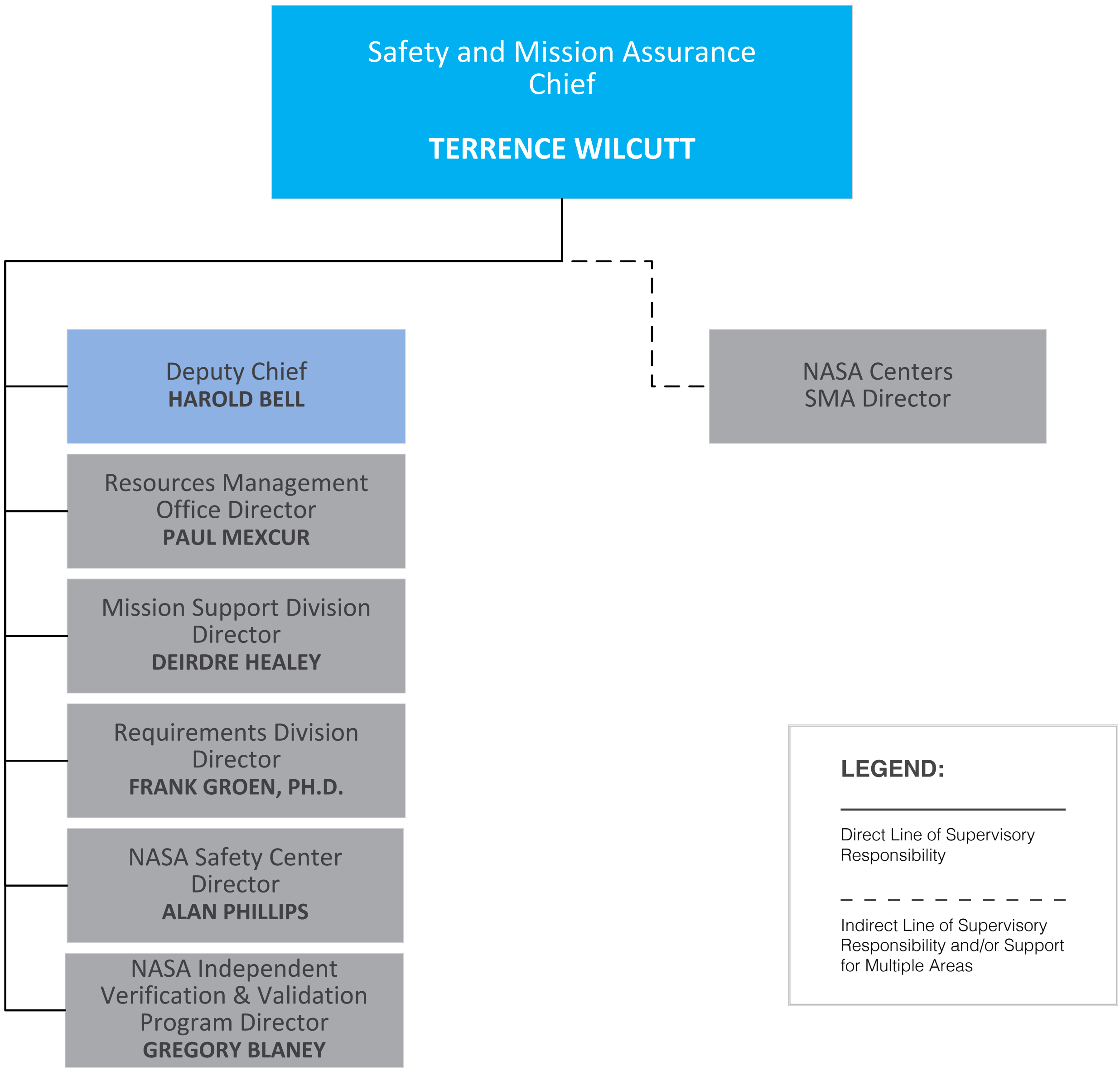


Figure 31.1 Office of Safety and Mission Assurance (OSMA) Organization Chart

CHIEF, SAFETY AND MISSION ASSURANCE

MR. TERRENCE W. WILCUTT

Terrence W. Wilcutt is the Chief, Safety and Mission Assurance, responsible for executive leadership, policy direction, functional management, and coordination for Agency-wide program and institutional safety and mission assurance activities. Mr. Wilcutt is a retired Marine Colonel and veteran astronaut who served as Director of Safety and Mission Assurance at NASA's Johnson Space Center. In that position, Mr. Wilcutt was tasked with the Safety Technical Authority of the programs and projects at JSC as well as JSC's Institutional Safety Program.

EXTENDED BIO - *https://sma.nasa.gov/about*

DEPUTY CHIEF, SAFETY AND MISSION ASSURANCE

MR. HAROLD M. BELL

Harold "Hal" Bell is the Deputy Chief, Safety and Mission Assurance, responsible for executive leadership, policy direction, functional management, and coordination for Agency-wide program and institutional safety and mission assurance activities. Prior to being appointed to this position, Mr. Bell was the NASA Deputy Chief Engineer, responsible for executive leadership and policy direction for the technical readiness of all NASA programs and projects.

EXTENDED BIO - *https://sma.nasa.gov/about*

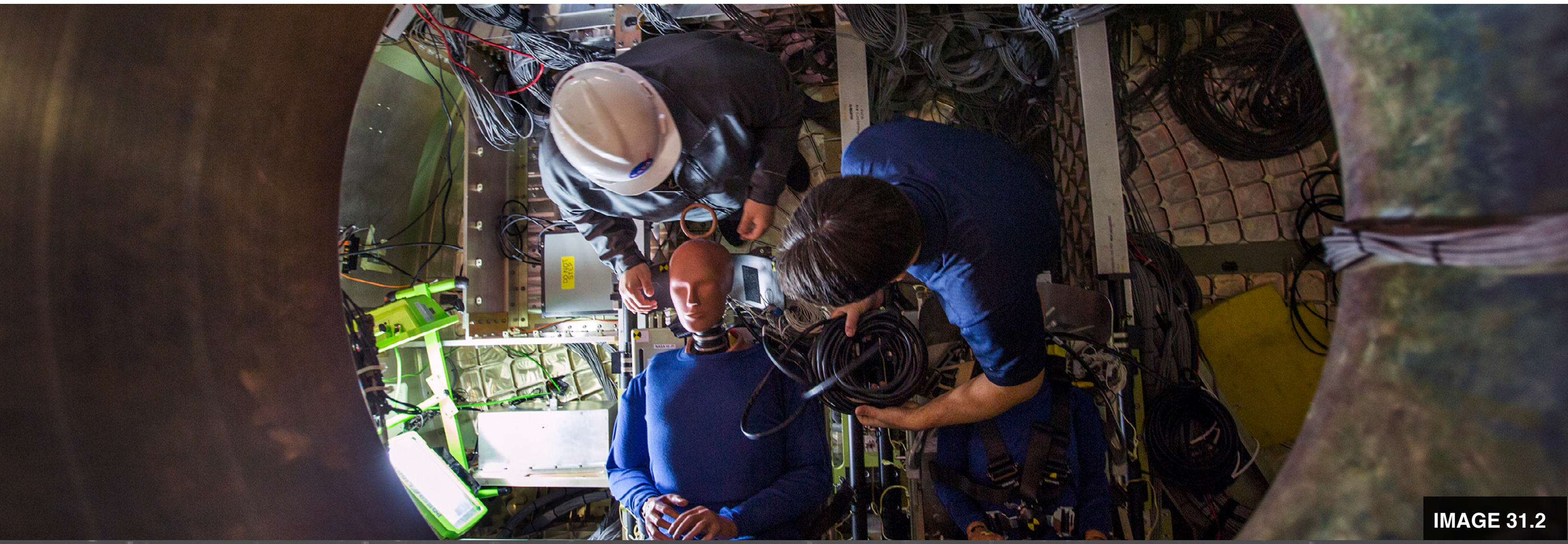


IMAGE 31.2

Figure 31.2 Office of Safety and Mission Assurance Workforce at a Glance

IMAGE 31.3

ORBITAL DEBRIS ENVIRONMENT CHARACTERIZATION

OSMA is pursuing high altitude space-based orbital debris measurement opportunities to fill a key data gap on millimeter-sized debris objects at the altitude of 700-1000 km. These objects represent the highest penetration risk to critical NASA and U.S. Earth observation and weather satellites in the region, but have never been directly measured. Such data is needed for the development of a high-fidelity environment model to support reliable orbital debris impact risk assessments and cost-effective impact shielding designs to protect space missions. OSMA has explored and advanced various debris impact detection technologies for more than 10 years, and has recently developed an innovative sensor suite that could meet the data collection requirements.

SMA TECHNICAL EXCELLENCE PROGRAM (STEP)

STEP is a 4-level qualification program (novice to expert) for the development/maturation of skills for Safety and Mission Assurance (SMA) engineering disciplines. The program is critical to enhance the safety and success of NASA's missions, as it fills the need for SMA engineering discipline training not traditionally offered in academia. Modeled after many professional certification programs, it includes a mixture of web-based and instructor-led training, on-the-job training, required reading, and non-traditional task assignments. STEP provides a repeatable set of curricula that accelerates learning/experience in support of NASA's mission, and provides learners the opportunity to build a strong intra-Agency discipline peer group. The program also addresses workforce attrition and turnover challenges, and replenishes scarce skill sets.

INDEPENDENT VERIFICATION AND VALIDATION (IV&V) PROGRAM CYBERSECURITY

The IV&V Program has established industry-leading cybersecurity tools and processes for vulnerability assessment, penetration testing, code analysis, risk assessment, secure development, and security training. This capability is currently being promulgated throughout NASA programs and missions, and will allow NASA to design security into new mission architecture, thereby decreasing vulnerability to cyber attacks. The vulnerability assessment capability can be used to determine the operational security posture of a system's critical network and infrastructure components through a unique, non-intrusive approach that can be applied to highly critical or fragile legacy systems. The training program includes a hands-on lab that allows both security novices and experts to act as white-hat hackers to enhance their understanding of today's top exploits. The Secure Coding Portal will provide information to software developers about the rules, guidelines, tools, resources, and requirements for coding securely.

IMAGE 31.4

RISK ACCEPTANCE (RA)

OSMA is working to improve both the technical basis for key decisions, especially RA decisions, and the efficacy of the management processes by which those decisions are made and communicated. Transferring Risk Management (RM) information and management accountability across organizational boundaries is a major challenge that has become more pressing with the commercialization of crewed launches. Recently, OSMA's work has focused on clarification of individual managers' accountability for RA decisions. This requires coordinated changes to multiple Agency directives and strengthening the roles of the Technical Authorities in RA decision-making, while streamlining the processes sufficiently to make them workable in NASA's development environment. To this end, OSMA has produced an interim directive for RM, and is coordinating changes to other affected directives. This initiative will formalize accountability for decisions affecting safety and mission success.

SAFETY CULTURE (SC)

OSMA champions SC improvements via assessment, education, engagement, and guidance, including completing the Agency-wide SC surveys to collect, understand, and apply results; continuing to implement SC training with employees; consulting with senior leaders via Organizational Safety Assessments (OSAs); and working to expand SC in NASA policy and guidance documents. Challenges exist across the workforce in terms of beliefs, values, and attitudes of employees at all levels, and opportunities for improvement exist. Senior leadership relies on the SC Program to routinely measure, educate, engage, and inculcate healthy SC practices across the Agency, and program outcome assessment findings provide leadership valuable feedback. A fully trained workforce allows all employees to understand what is expected of them, and direct engagement via the OSAs encourages proactive leadership. Ultimately, a robust safety culture leads to enhanced safety and mission success.

IMAGE 31.5

OFFICE OF SMALL BUSINESS PROGRAMS (OSBP)

MISSION STATEMENT

The Office of Small Business Programs (OSBP) ensures that the Agency is compliant with all Federal laws, regulations, and policies regarding small and disadvantaged business utilization, and provides expertise on the utilization of all categories of innovative small business, including minority educational institutions that can deliver technical solutions in support of NASA.

OFFICE WEBSITE - *http://osbp.nasa.gov/*

IMAGE 32.1

OFFICE OF SMALL BUSINESS PROGRAMS CORE FUNCTIONS

ADVOCACY
Advise the Administrator on all matters related to small business.

SMALL BUSINESS FOCUSED GOVERNMENT CONTRACTING
Develop small businesses in high tech areas that include technology transfer and commercialization of technology, and maximize the number of practicable opportunities for small business participation in NASA prime contracts and subcontracts.

PROMOTE SMALL BUSINESS
Develop and manage NASA programs that assist all small business categories and communities.

ENTREPRENEURIAL DEVELOPMENT
OSBP and NASA Centers provide individual face-to-face and internet counseling for small businesses throughout the United States and US territories.

OFFICE OF SMALL BUSINESS PROGRAMS ORGANIZATION

The Small Business Act requires all federal agencies with contracting authority to establish an Office of Small and Disadvantaged Business Utilization (OSDBU). At NASA, the OSDBU has been re-named the Office of Small Business Programs (OSBP) to reflect the inclusion of all categories of small business in the Agency's activities. Headed by the Associate Administrator and supported by four Program Managers, the OSBP develops and implements NASA's small business initiatives in compliance with federal laws, regulations, and policies.

The organizational chart provides insight into the official roles and relationships within OSBP.

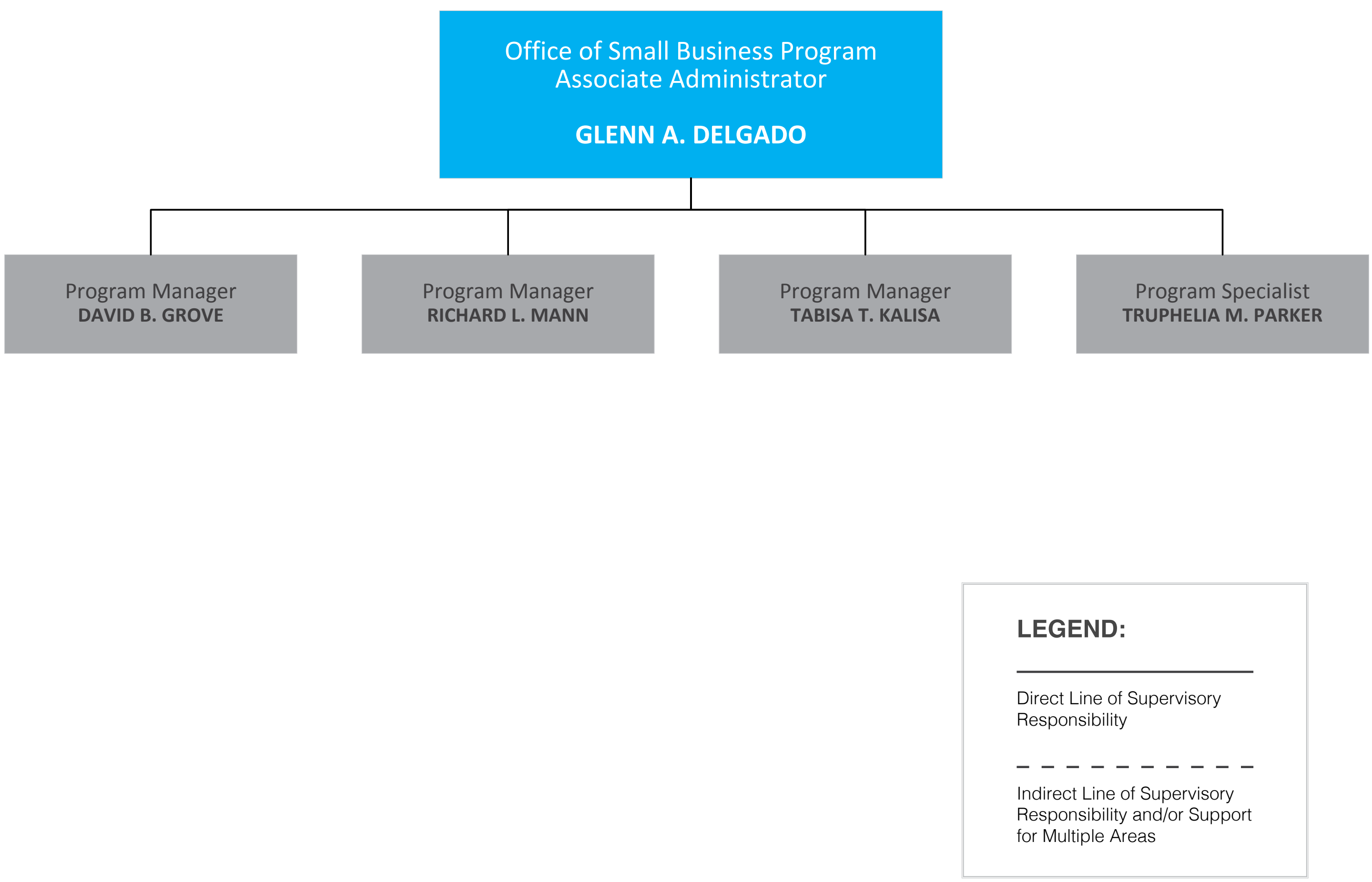


Figure 32.1 Office of Small Business Programs (OSBP) Organization Chart

ASSOCIATE ADMINISTRATOR
GLENN A. DELGADO

Mr. Glenn A. Delgado is the Associate Administrator of the NASA Office of Small Business Programs. Since Mr. Delgado's arrival at NASA in fiscal year (FY) 2007, the direct awards to small businesses have increased 27%, which equates to approximately $525 million. Mr. Delgado has served as the Chairman of the Executive Committee of the Federal Office of Small and Disadvantaged Business Utilization (OSDBU) Directors Council in FY 2009, FY 2014, and FY 2015, and was the recipient of the Presidential Rank Award of Meritorious Executive.

During his tenure as the Associate Administrator of NASA's Office of Small Business Programs, Mr. Delgado and his team have worked very closely with the Office of the General Counsel and the Office of Procurement to publish several new policies, contract clauses, and NASA Federal Acquisition Regulation (FAR) Supplement changes that are very beneficial to the Agency's small business program. The Small Business Administration recognized some of the new policies and procedures that NASA implemented for its small business program as Federal Government Best Practices.

EXTENDED BIO - *http://www.nasa.gov/about/highlights/delgado_bio.html*

IMAGE 32.2

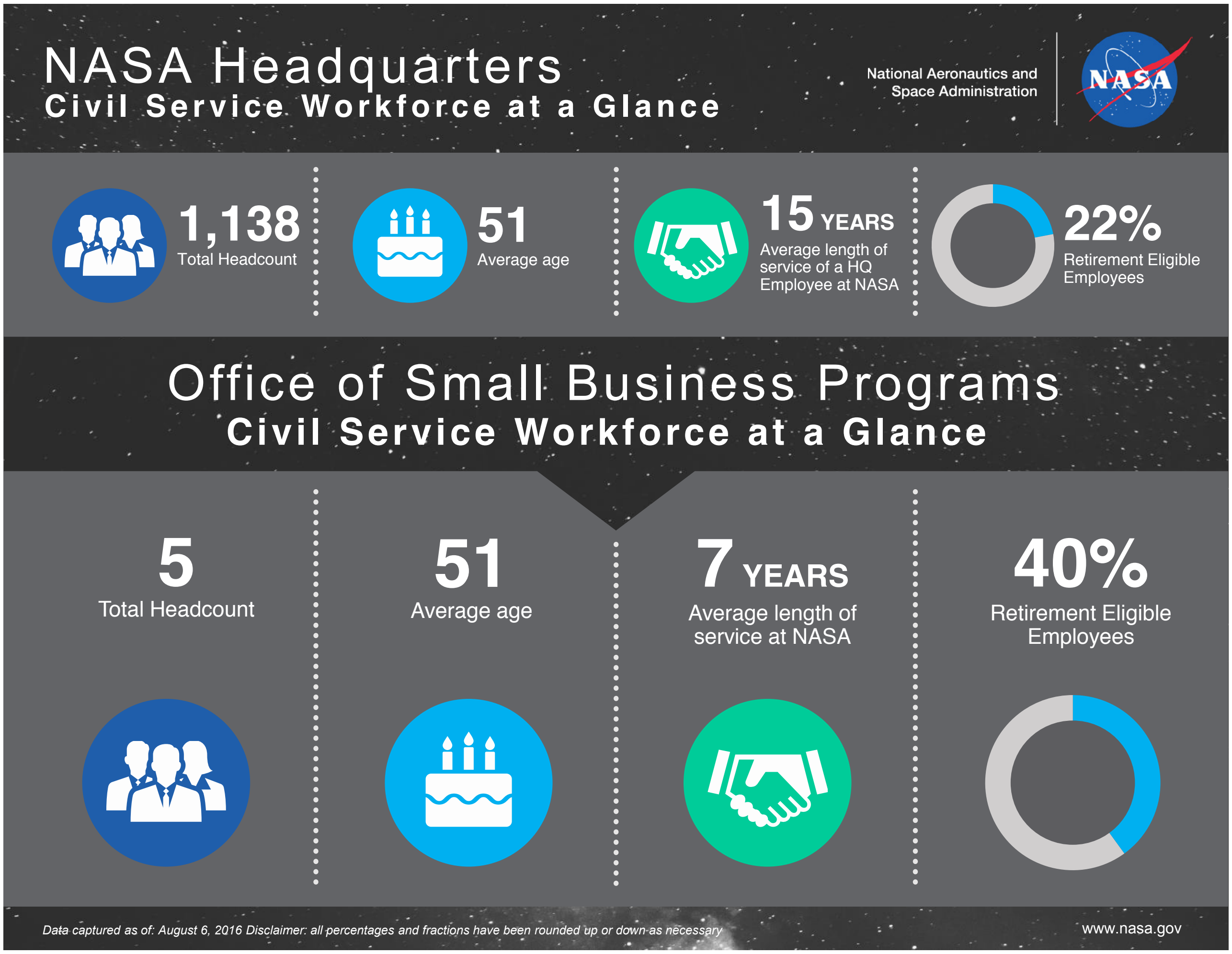


Figure 32.2 Office of Small Business Programs Workforce at a Glance

IMAGE 32.3

The NASA Small Business Improvement Plan (SBIP) is the focal point of the Agency's platform as it relates to strategic planning for small business. It is an ambitious effort to build consensus across NASA regarding small business promotion and utilization. Agency-wide participation from small business specialists, procurement, legal, and technical program organizations validates commitment to this collaborative effort. For FY 2016 and FY 2017 the Agency's SBIP initiatives are:

SMALL BUSINESS SUBCATEGORY IMPROVEMENT

Improve Agency performance in small business subcategories by identifying, increasing, and promoting small business prime contracting opportunities. One of the ways that NASA OSBP improves subcategory improvement is through the Mentor-Protégé Program which encourages NASA prime contractors to assist eligible protégés, thereby enhancing the protégés' capabilities to perform on NASA contracts and subcontracts, fostering the establishment of long-term business relationships between these entities and NASA prime contractors, and increasing the overall number of these entities that receive NASA contract and subcontract awards. Another focused effort is collaboration at the Center-level between the small business office and procurement to discuss scope, contract type, set-aside considerations, North American Industry Classification System (NAICS) codes, and market research requirements. The small business specialist at each Center is fully engaged in the procurement planning process, pre-award activities, and acquisition strategy process, with the goal of increasing set-aside and subcontracting opportunities for small business. As reported in the Mid-year Small Business Program Report on June 15, 2016, a total of 116 set-asides to small business have occurred at the Center-level.

ADVOCACY

Promote small business programs through advocacy and collaborative efforts with internal and external partners/stakeholders. The Office of Small Business Programs (OSBP), in collaboration with the Office of Education and the Space Technology Mission Directorate, implemented a Historically Black Colleges and Universities/Minority Serving Institutions (HBCU/MSI) initiative in 2016. This initiative is referred to as the "NASA HBCU/MSI Technology Infusion Road Tour" and is a pilot designed to assist NASA and Large Prime Contractors meet and/or exceed the Agency mandated HBCUs/MSI goals. In addition, the Road Tour provides HBCUs/MSIs an introduction and a platform to seek NASA and Large Prime Contractors to pursue non-grant funding. NASA OSBP has Memorandums of Understanding (MOUs) with the Information Technology and Communication Division, Space Technology Mission Directorate, Office of Strategic Infrastructure, and the Office of the Chief Technologist. NASA OSBP also promotes external collaboration via Space Act Agreements with groups hosting regional outreach events where the Agency can participate in outreach in locations where there is no NASA Center and/or presence. In FY 2016, such agreements have been made with the Jefferson County Economic Development Corporation and the Smaller Business Association of New England, Inc.

IMAGE 32.4

OUTREACH

Promote small business awareness and participation, utilizing innovative techniques at NASA Centers and nontraditional venues in geographically targeted areas, to enhance all categories of small business. Initiated as part of the FY 2012 NASA Small Business Improvement Plan (SBIP), the Agency began hosting small business industry day events around the country, at NASA Centers, to engage and create a dialogue with companies interested in doing business with NASA. Specifically, OSBP and the Centers established annual Agency-wide industry days in conjunction with an emphasis on Service-Disabled Veteran-Owned Small Businesses, Historically Underutilized Business Zone concerns, and Women-Owned Small Businesses. The Agency's commitment to this effort continues until NASA meets and/or exceeds all congressionally mandated small business goals. In FY 2016 NASA targeted its small business outreach efforts further and implemented an initiative to participate in regional outreach events to locations where there is no Center and the Agency does have a traditional presence. To support this effort, the OSBP, through Space Act Agreements, collaborates with state and local governments to reach companies interested in doing business with NASA.

ADDITIONAL RESOURCES

- www U.S. Small Business Administration
- www NASA Acquisition Forecast
- www Federal Business Opportunities
- www BusinessUSA
- NASA FY 2015 Small Business Industry Awards

OFFICE OF THE CHIEF ENGINEER (OCE)

MISSION STATEMENT

The Office of the Chief Engineer (OCE) provides policy direction, oversight, and assessment for the NASA engineering and program management communities and serves as principal advisor to the NASA Administrator and other senior officials on matters pertaining to the technical readiness and execution of NASA programs and projects. The OCE ensures that NASA's development efforts and mission operations are planned and conducted on a sound engineering basis with proper controls and management of technical risks.

OFFICE WEBSITE *- http://www.nasa.gov/offices/oce/home/index.html*

IMAGE 33.1

OFFICE OF THE CHIEF ENGINEER CORE FUNCTIONS

TECHNICAL ADVISORY AND AUTHORITY

- Advise Agency leadership on the technical and programmatic readiness of NASA programs and projects.
- Execute Agency's Engineering Technical Authority. Employs checks and balances among key organizations to ensure that decisions have the benefit of different points of view and are not made in isolation.
- Steward engineering disciplines through Technical Capability Leadership.

SPACE ASSET PROTECTION

Implement the Space Asset Protection Program to satisfy the National Space Policies, Presidential Policy Directive (PPD)-4 and PPD-21 that require the protection of all critical space systems and supporting infrastructure

TECHNICAL ASSESSMENT

Provide value-added independent technical assessments across NASA's programs via the NASA Engineering and Safety Centers (NESC).

AGENCY PROGRAM/PROJECT AND KNOWLEDGE MANAGEMENT EXPERTISE AND TRAINING

- Steward Agency-level policy and standards for engineering, knowledge, and program and project management.
- Share program/project management and engineering best practices, and lessons learned. Support the workforce with training and knowledge management services needed to continuously improve program/project management and engineering skills.
- Serve as the Agency's focal point for developing the policies and requirements necessary to integrate knowledge capture across programs,projects, and Centers.

OFFICE OF THE CHIEF ENGINEER ORGANIZATION

The OCE provides executive leadership for the effective management of all OCE programs, resources, and external requirements for OCE. The NASA Engineering and Safety Center develops rapid, cross-Agency response to mission critical engineering issues, and works proactively to help NASA avoid problem recurrence and to prevent future problems. The Engineering Policy, Practice, and Development Division provides policy and practice direction for the Agency's engineering community. The Technical Standards Program, NASA Engineering Network, and the Space Asset Protection Program are also in this division. The Program and Project Management and Development Division develops program and project management policy and establishes Agency-wide process and requirements for program/project management. This division serves as the Agency lead for Earned Value Management and manages the NASA's Academy of Program, Project, and Engineering Leadership.

The organizational chart provides insight into the official roles and relationships within OCE.

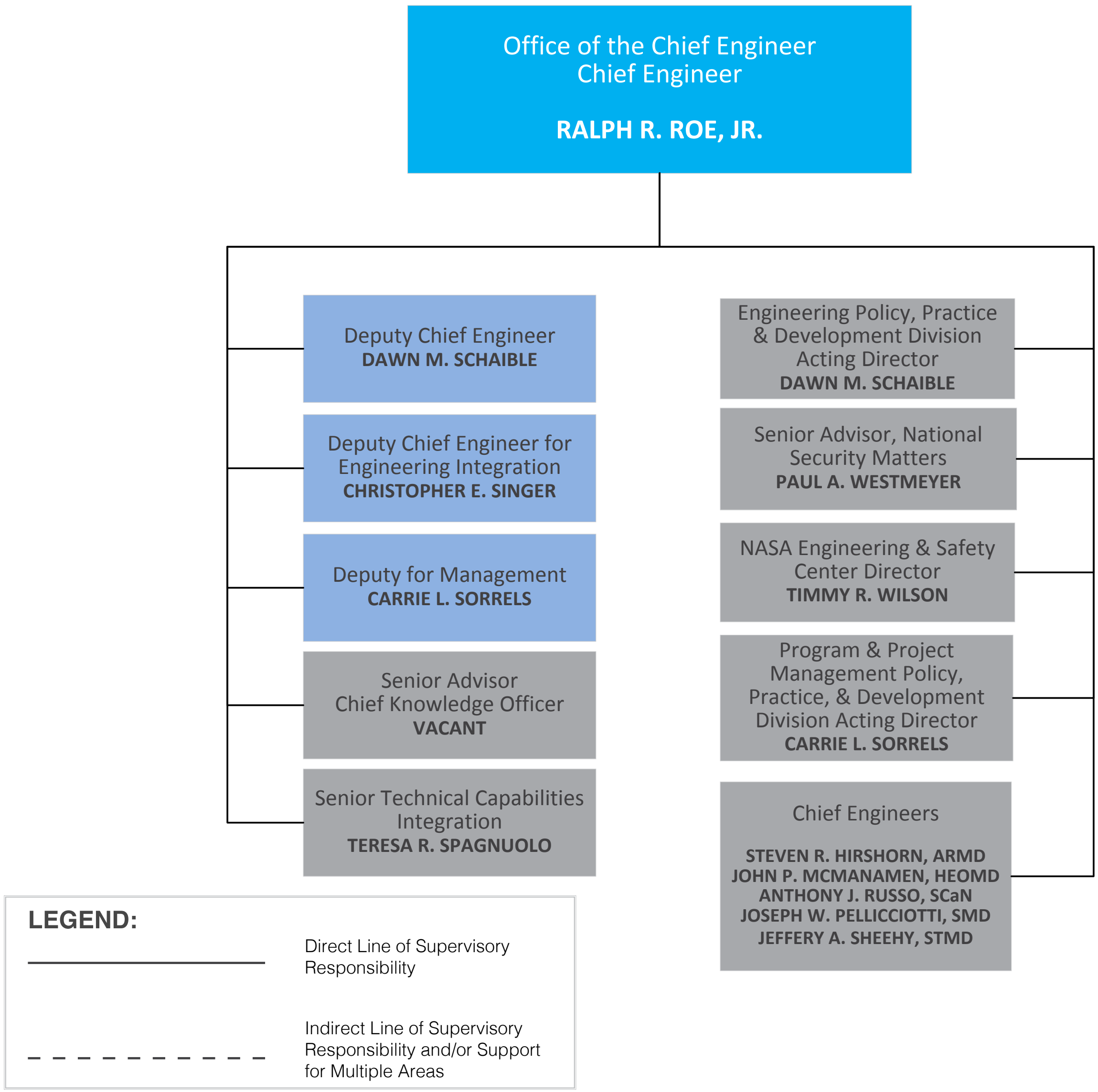


Figure 33.1 Office of the Chief Engineer (OCE) Organization Chart

CHIEF ENGINEER

MR. RALPH R. ROE, JR.

Since February 2014, Ralph R. Roe, Jr. has been NASA's Chief Engineer after serving as the first director of the NASA Engineering and Safety Center since 2003. He joined NASA in 1983 as a Propulsion Systems Test Engineer at Kennedy Space Center (KSC), held a number of management positions within Space Shuttle Engineering at KSC, and then served as the Space Shuttle Launch Director for four missions including the first International Space Station flight. From 1999 to 2003, Mr. Roe served as Manager of the Space Shuttle Vehicle Engineering Office at the NASA Johnson Space Center (JSC) where he was responsible for the Orbiter fleet, flight software, flight crew equipment, and robotic arm. He has a B.S. in Mechanical Engineering from the University of South Carolina and a M.S. in Engineering Management from the University of Central Florida.

EXTENDED BIO - *http://www.nasa.gov/offices/oce/team/Ralph_Roe_bio.html*

DEPUTY CHIEF ENGINEER

MS. DAWN M. SCHAIBLE

Ms. Schaible was appointed as the NASA Deputy Chief Engineer in July 2014, where she is leading the implementation of the OCE's role in Agency Technical Capability Leadership. She was previously the Manager of the Systems Engineering Office for the NASA Engineering and Safety Center (NESC) at the Langley Research Center, providing systems engineering expertise to the independent NESC assessments of critical, high-risk issues. Prior to joining Langley in 2005, Ms. Schaible spent 18 years at KSC where she held a number of lead engineering positions for the Space Shuttle and International Space Station Programs. Ms. Schaible earned a B.S. in Mechanical Engineering from Bradley University and M.S. degrees from the Florida Institute of Technology and the Massachusetts Institute of Technology.

IMAGE 33.2

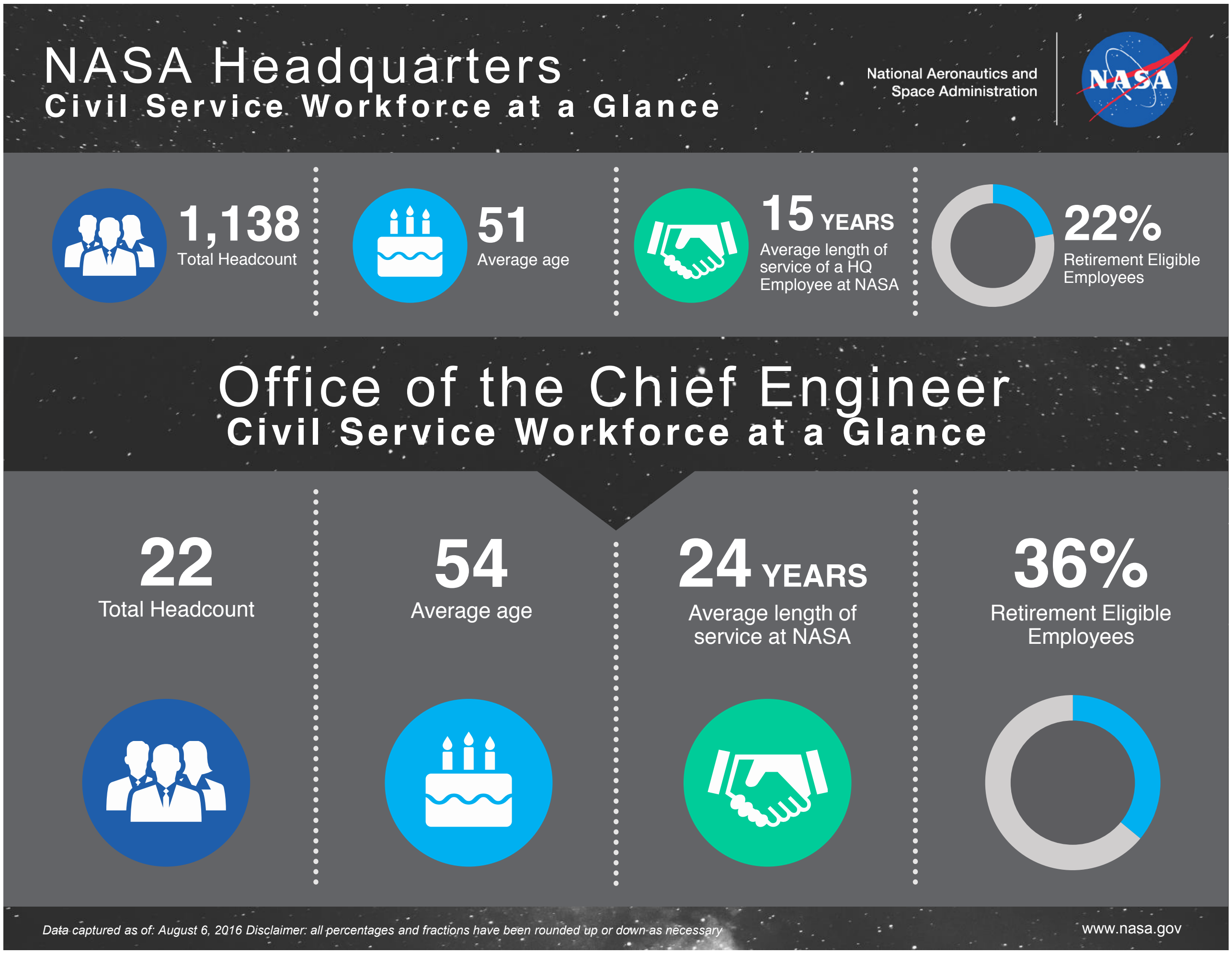


Figure 33.2 Office of the Chief Engineer Workforce at a Glance

IMAGE 33.3

TECHNICAL CAPABILITY LEADERSHIP

The Office of the Chief Engineer has assumed the responsibility to lead both the discipline-level and system-level Technical Capability Leadership on behalf of the Agency. This effort helps NASA make strategic investments in technical capabilities that are needed for our future missions. OCE provides guidance and coordination for the technical assessment process and facilitates communication and integration across the Technical Capability (discipline) areas. NASA Technical Fellows serve as Technical Capability Leaders for their discipline areas. NASA Technical Fellows and their respective Agency-wide teams are responsible for assessing/baselining their discipline and developing recommendations to ensure their capability is ready to support current and future missions. NASA Technical Fellows and their Capability Leadership Teams will provide an initial technical assessment (taking into account all aspects - workforce, facilities and equipment/tools, etc.) to assess the health of their capability and will expand/dive deeper each subsequent year.

PROGAM AND PROJECT MANAGEMENT

The Office of the Chief Engineer is responsible for the formulation and implementation of Agency-wide planning and policy designed to strengthen Program and Project Management, to ensure appropriate visibility and resolution of Program and Project Management issues within the Agency, and make recommendations regarding Agency Program and Project Management policy, processes, initiatives, and systems. The policy establishs the framework and process by which NASA formulates and implements programs and projects consistent with the governance model NPD 1000.0, NASA Governance and Strategic Management Handbook, and establish a standard of uniformity in the management of programs and projects.

CHIEF KNOWLEDGE OFFICE (CKO)

The Chief Knowledge Officer reports to the Chief Engineer and ensures that NASA has an integrated and formal Knowledge Management strategy and implementation plan to address how knowledge is created, retained, shared, and transferred throughout the Agency and its partners and contractors. The CKO maintains an Agency process (Knowledge Referee Process) that addresses continuous and risk-informed knowledge and lessons learned through an integrated knowledge services framework, prioritization of critical knowledge, and formal incorporation into appropriate policies and technical standards. The CKO enables access to critical knowledge to Agency practitioners when they need it now and in the future, thereby increasing our likelihood of mission success.

! ADDITIONAL RESOURCES

- WWW [NESC Website]
- WWW [Lessons Learned Information System]

OFFICE OF THE CHIEF FINANCIAL OFFICER (OCFO)

MISSION STATEMENT

The Office of the Chief Financial Officer (OCFO) provides leadership for NASA's strategic planning, performance reporting, budget formulation and analysis, as well as justification, control, and reporting of all Agency fiscal resources, provides leadership for the Agency's communications on all matters with the House and Senate Committees on Appropriations, oversees all financial management activities relating to the programs and operations of the Agency, and monitors and reports the financial execution of the Agency budget. The OCFO manages the Agency's budget and financial operations, leads the Agency's programmatic analysis capabilities, directs the preparation and submission of annual financial and budgetary reports, and coordinates Agency financial management activities with other federal agencies.

OFFICE WEBSITE *- http://www.nasa.gov/offices/ocfo/home/*

IMAGE 34.1

OFFICE OF THE CHIEF FINANCIAL OFFICER CORE FUNCTIONS

AGENCY FINANCIAL MANAGEMENT

Provides oversight, policy guidance, and financial management of Agency resources and activities (including the centers). Monitors the financial execution of the Agency budget, monitors quality and performance of ongoing financial activities, and prepares and transmits timely audits, financial, and performance reports to the Administrator, the Director of the Office of Management and Budget, the congressional committees of jurisdiction, and other authorities who review NASA's financial matters.

AGENCY BUDGETING AND RESOURCE MANAGEMENT

Provides leadership in the development and presentation of the annual Agency budget. Reviews, assesses, and validates Agency resources, requirements, and requests on the basis of strategic alignment, priorities, quality, and performance, including recommendations to the Administrator for fiscal resources approvals and authorizations.

APPROPRIATIONS

Provides critical executive leadership, direction and coordination of all communications between NASA and the House and Senate Committees on Appropriations.

AGENCY PROGRAMMATIC ANALYSIS CAPABILITY (APAC) LEADERSHIP

Provides APAC leadership and serves as the Programmatic Standards and Policies Owner and Programmatic Competency Steward. This includes cost and schedule policies and key Agency programmatic standards, processes, and tools to maintain the quality and independence of Agency programmatic assessment capability.

RISK MANAGEMENT

Provides overall coordination, implementation, and integration of NASA's risk-based Internal Control Program, Enterprise Risk Management (ERM), and Internal Control Assessments and Quality Assurance Reviews, designed to improve Agency management. Manages and facilitates the preparation of the Administrator's annual Statement of Assurance.

AGENCY STRATEGIC PLANNING AND PERFORMANCE MANAGEMENT

Oversees all strategic planning and performance management activities relating to the programs and operations of the Agency.

IMAGE 34.2

OFFICE OF THE CHIEF FINANCIAL OFFICER ORGANIZATION

The OCFO was established in accordance with the Chief Financial Officers Act of 1990 (CFO Act), Public Law 101-576. The NASA CFO is a Presidentially appointed, Senate confirmed position. Most of the OCFO staff are physically located at NASA HQ, although some are physically located at NASA's field Centers, including the Center CFOs. The Center CFOs report directly to the Agency CFO, and manage Agencywide activities throughout the year from the Center perspective. OCFO has been a leader in NASA regarding the implementation of telework, with much of the staff teleworking as many as 3 days per week.

The NASA CFO has four Deputies who are direct reports to the CFO, and most of the work of the OCFO is performed by six Divisions as depicted in the organization chart. In addition, some of the larger Divisions have multiple branches. Additional information on the OCFO organization and roles is represented in the organizational chart.

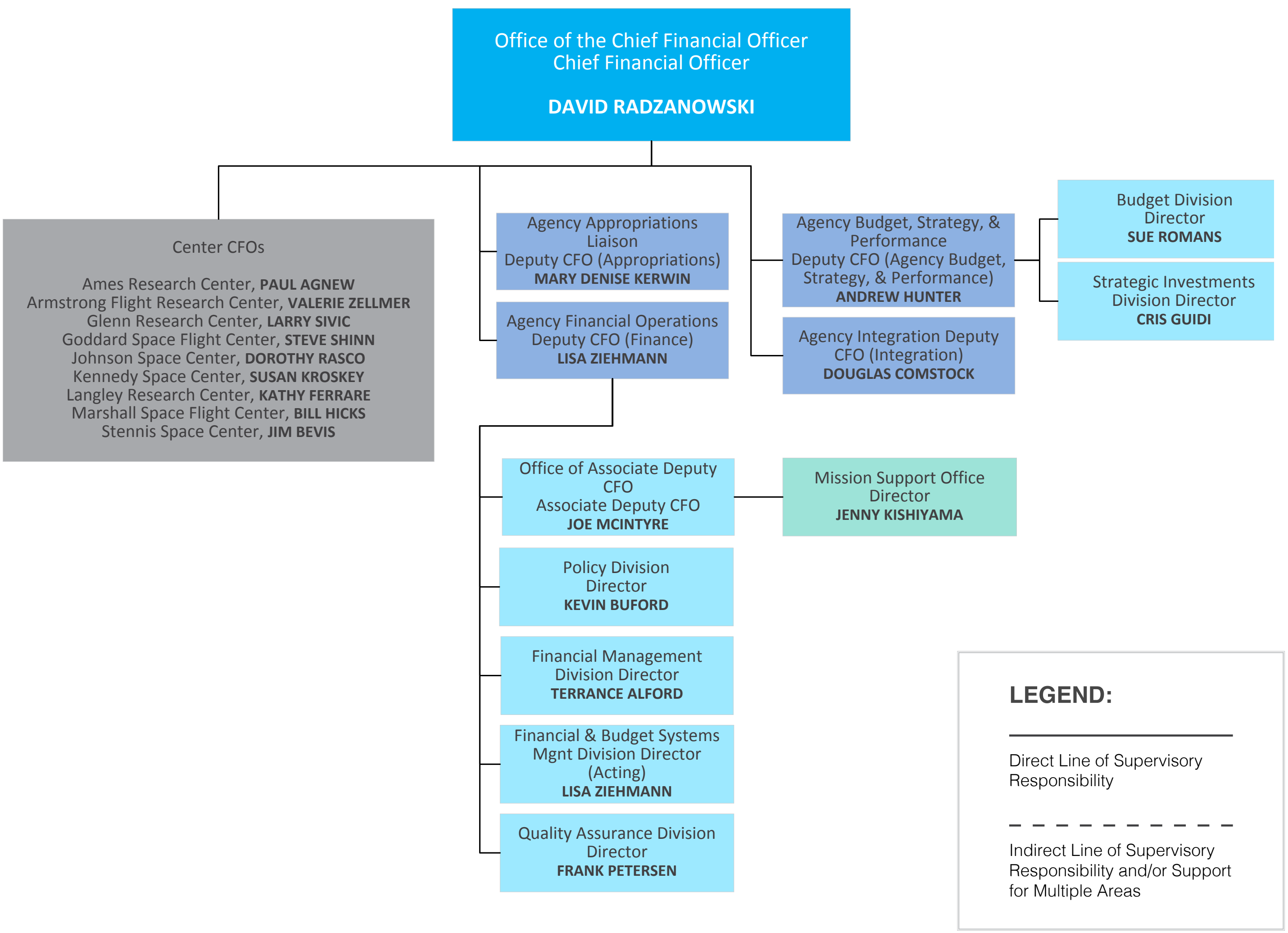


Figure 34.1 Office of the Chief Financial Officer Organization Chart

CHIEF FINANCIAL OFFICER
MR. DAVID RADZANOWSKI

David Radzanowski is the NASA Chief Financial Officer, confirmed by the U.S. Senate as the NASA CFO on October 7, 2014. He ensures the financial health of the organization, and is responsible for ensuring that NASA resources are effectively employed toward the achievement of NASA's strategic plan. Previous NASA positions include Chief of Staff, in May of 2010, as well as leadership positions in the Space Operations Mission Directorate. Prior to NASA, he served eight years at the White House Office of Management and Budget (OMB) including positions as Deputy Associate Director for Appropriations, and Chief of the Science and Space Programs Branch. Prior to joining OMB, he served eight years as an analyst in aerospace policy for the Congressional Research Service.
EXTENDED BIO - *http://www.nasa.gov/about/highlights/Radzanowski_bio.html*

DEPUTY CHIEF FINANCIAL OFFICER FOR BUDGET, STRATEGY, AND PERFORMANCE
MR. ANDREW HUNTER

Andrew Hunter, Deputy Chief Financial Officer for Budget, Strategy, and Performance, joined NASA in 1988. Prior to his position with the Office of the NASA Chief Financial Officer, Mr. Hunter served as Director of Resources for NASA's Exploration Systems Mission Directorate from 2005 to 2010. Prior to that position, he was Budget Director for the Earth Science Program for seven years. Mr. Hunter has had several leadership development activities including a detail with the CFO of the National Geographic Society, and as Deputy for Human Resources at Langley Research Center.
EXTENDED BIO - *http://www.nasa.gov/offices/ocfo/leadership/Andrew_Hunter*

DEPUTY CHIEF FINANCIAL OFFICER FOR FINANCE
MS. LISA ZIEHMANN

Lisa Ziehmann is the Deputy Chief Financial Officer (CFO) for Finance at the National Aeronautics and Space Administration (NASA), where she is responsible for Senior Executive oversight for the Agency's financial operations and reporting, policy development, financial audit, and internal controls. Ms. Ziehmann has over 29 years of experience in Federal government financial management, budget, and enterprise-wide business systems development. Most recently, she was the Director for Financial Policy and Operations at the General Services Administration (GSA) in Washington, D.C. Before joining GSA, Ms. Ziehmann served as the Deputy Budget Director for NASA in Washington, D.C.
EXTENDED BIO - *http://www.nasa.gov/offices/ocfo/leadership/Lisa_Ziehmann*

DEPUTY CHIEF FINANCIAL OFFICER FOR APPROPRIATIONS

MS. MARY DENISE KERWIN

Mary Denise Kerwin is Deputy Chief Financial Officer (CFO) for Appropriations for NASA. Ms. Kerwin is responsible for leadership of all matters pertaining to presentation of, and advocacy for, NASA's annual budget requests to Congress, ensuring that NASA's budget and programs are communicated effectively and consistently to Congress, and securing appropriations outcomes that maximize the President's program for NASA. Previous NASA positions include Deputy Associate Administrator for Legislative and Intergovernmental Affairs, Deputy Comptroller for Appropriations, Deputy Associate Administrator for Legislative Affairs (Programs), and Director of the Congressional Liaison Division.

EXTENDED BIO - *http://www.nasa.gov/offices/ocfo/leadership/Mary_Denise_Kerwin*

DEPUTY CHIEF FINANCIAL OFFICER FOR INTEGRATION

MR. DOUG COMSTOCK

Doug Comstock is the Deputy Chief Financial Officer for Integration, reporting to the CFO. He joined NASA in 2002, and has served as Director of the Cost Analysis Division leading implementation of cost policies including Joint Cost and Schedule Confidence Level (JCL) analysis, Director of the Innovative Partnerships Program leading a technology development portfolio including small businesses, partnerships, and incentive prize competitions, NASA Comptroller, and Director of the Strategic Investments Division. Before joining NASA, he served in the Office of Management Budget from 1998-2002. Prior to government service he spent 15 years in industry, including Director of Engineering at the Futron Corporation, and advanced concept development with General Dynamics Space Systems.

EXTEDNED BIO - *http://www.nasa.gov/offices/ocfo/leadership/Doug_Comstock*

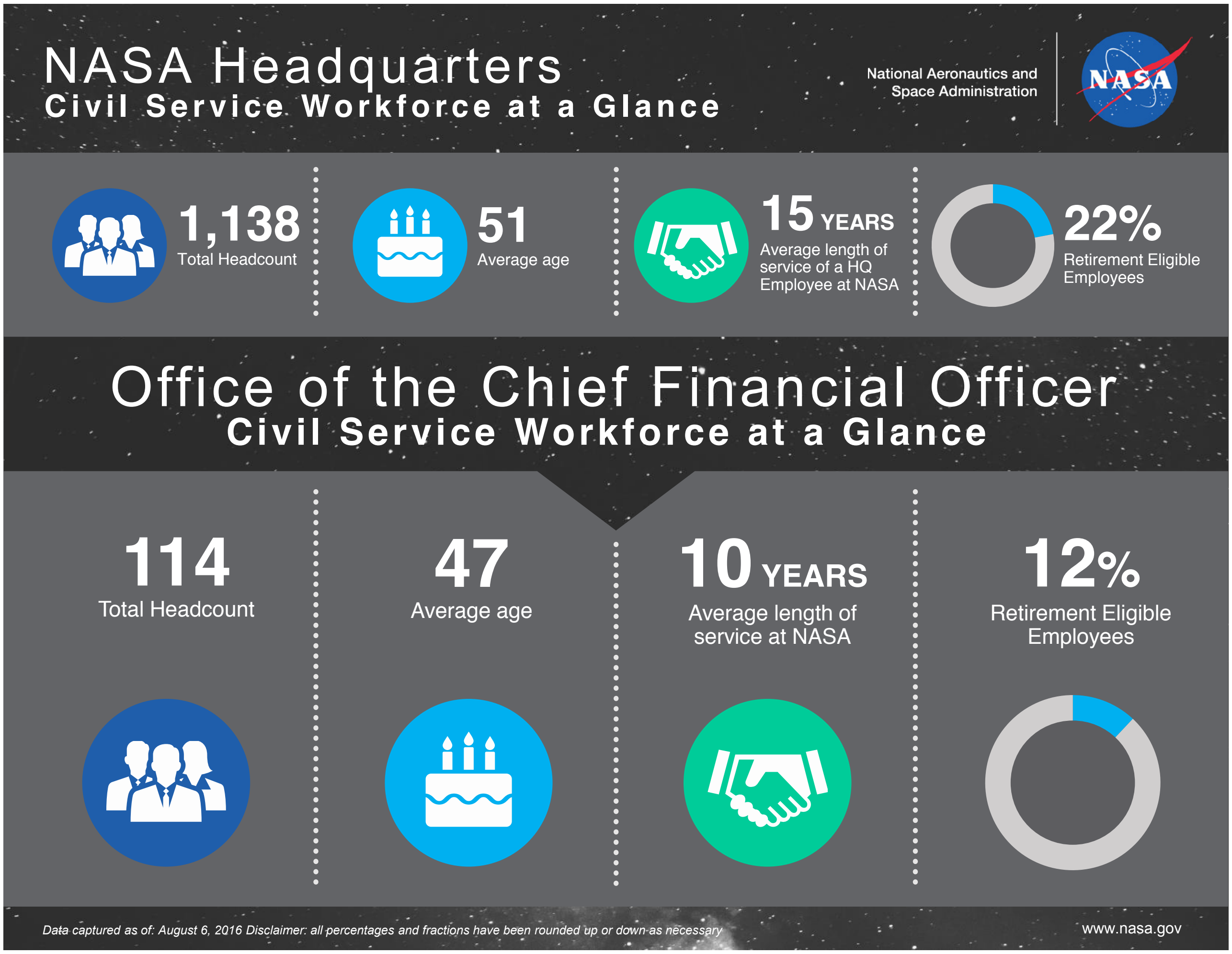


Figure 34.2 Office of the Chief Financial Officer Workforce at a Glance

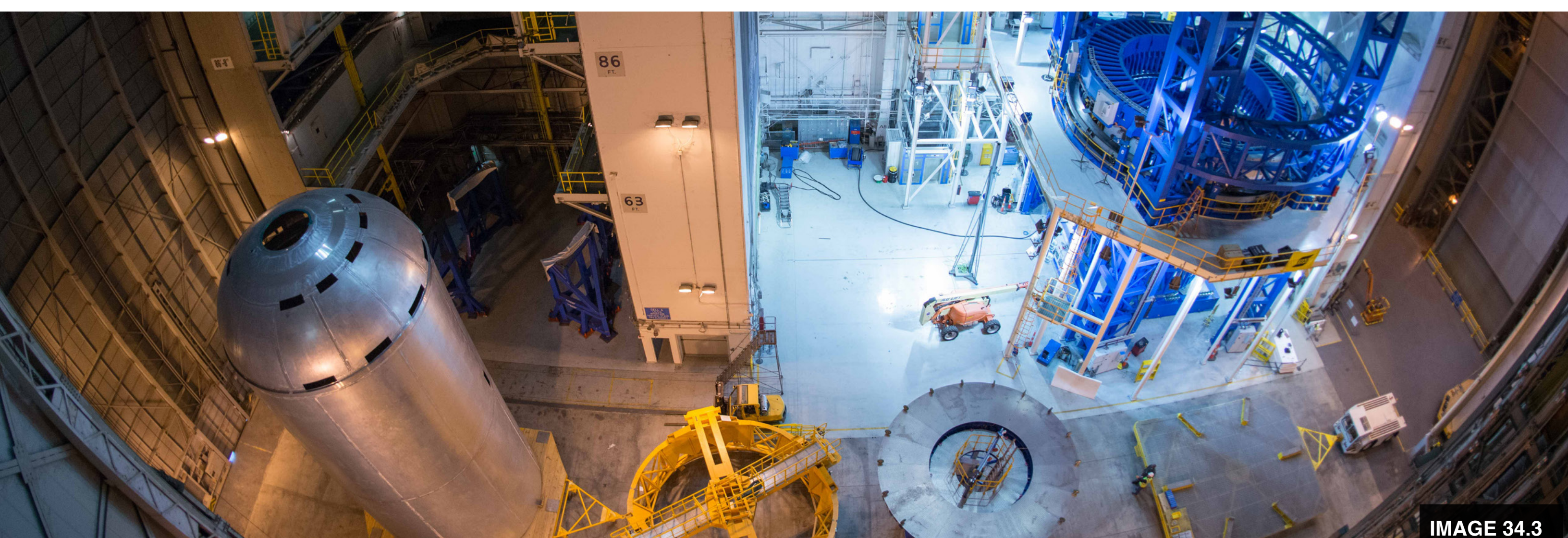


IMAGE 34.3

BUDGET BUSINESS SERVICES ASSESSMENT (BSA)

Through the execution of the Business Services Assessment (BSA), NASA is defining the health of each business service area, identifying opportunities for optimization, and developing risk informed recommendations to establish a more efficient operating model that maintains a minimum set of capabilities and meets current and future mission needs. The Budget BSA assessed the health and resources required to conduct the Agency's Planning, Programing, Budgeting, and Execution (PPBE) process. It was charged to assess value to effort expended, decrease the amount of effort spent in budget formulation and execution and find best practices. Observations include: The NASA executed PPBE process is healthy, dynamic and robust, and adaptive and responsive to changes. Stakeholders are positive about OCFO products and services. While the NASA budget process is benchmarked as a government leader, there are opportunities to improve current processes with management attention, communication, behavior modification, and education of stakeholders. However, one size will not fit all. The Mission Support Council (MSC) will consider the recommendations of the Budget BSA in November, then implementation will begin based on MSC decisions.

BUSINESS PROCESS DESIGN AND DOCUMENTATION (BPDD)

The OCFO has undertaken a BPDD project to document and streamline key business processes including Travel, Reimbursable Agreements, and Real Property (in partnership with the Office of Strategic Infrastructure). The project is identifying opportunities for optimization through standardization, streamlining, and consolidation. The opportunities for optimization are evaluated and prioritized based on level of impact on the process and the level of effort required for implementation. Travel is the furthest along, and has begun to implement recommendations that standardize forms and simplify the approval process, and has initiated a costsaving pilot on use of nonrefundable tickets, and a consolidation of travel functions between ARC and AFRC. The Real Property and Reimbursable efforts are defining standardized process maps and identifying areas for improvement incorporating best practices.

ENTERPRISE RISK MANAGEMENT (ERM)

The OCFO is leading development of an ERM framework to formalize the integration of risk management into the decision making process across the Agency, consistent with new guidance from OMB Circulars A-123 and A-11. The ERM initiative seeks to ensure that Agency-level risks are identified and proactively managed, to reduce the impacts of those risks in the future. This will include accountability, collaboration, and coordination of NASA's strategic, management, and operational activities through the integration of current internal control systems, processes, and activities. The approach seeks to leverage NASA's existing risk management structure to yield the desired outcomes and ensure compliance with limited resources. Thus far, the ERM approach is leveraging NASA's culture of risk management activities, with the Chief Operating Officer/Associate Administrator (COO/AA) at the helm, and will build on established risk management activities underway across the Agency such as BSA and BPDD to name a few.

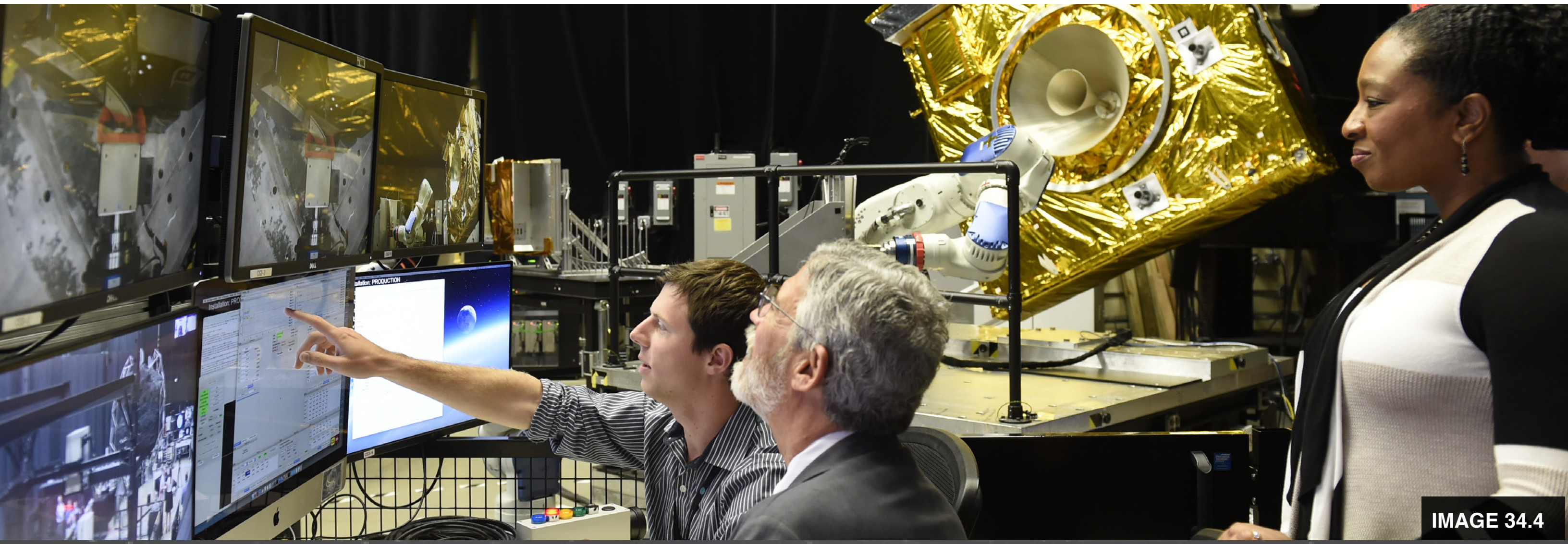


IMAGE 34.4

AGENCY PROGRAMMATIC ANALYSIS CAPABILITY (APAC) LEADERSHIP

The Office of Chief Financial Officer (OCFO) assumed the role of Agency Programmatic Analysis Capability (APAC) Leadership and serves as the Programmatic Standards and Policies Owner and Programmatic Competency Steward. The OCFO has ownership of NASA cost and schedule policies and key Agency programmatic standards, processes, and tools to maintain the quality and independence of Agency programmatic assessment capability. The APAC role also empowers OCFO as the Agency Programmatic Capability Steward to assess the health of the cost and schedule analysis workforce and address needed improvements or gaps, assist the mission directorates in the identification of personnel with prerequisite skills, provide Agency-wide tools for programmatic analysis, and facilitate training. To date, the transition to this new model has been executed without any disruption in service and quality of independent reviews.

CHIEF FINANCIAL OFFICER UNIVERSITY

The NASA Chief Financial Officer (CFO) community seeks to be credible experts, trusted advisors, and sources of quality information on matters related to finance and resources, including the management of associated risk for NASA programmatic and institutional decision-making. This requires the community to have the right tools, advanced knowledge, competencies, and experience. Continued training and development of NASA's finance and resource workforce is essential to meeting this demand. The CFO University was established in 2008 in order to train our internal workforce and provide NASA-specific financial and resources management courses. To date, over six thousand employees across the Agency have participated in training provided by CFO University and it has become an invaluable resource for the Agency through knowledge-sharing and assisting in the professional development of our workforce.

ADDITIONAL RESOURCES

- WWW Budget Documents, Strategic Plans, and Performance Reports
- WWW NASA Cost Estimating Handbook
- WWW CFO 2016 Priorities

OFFICE OF THE CHIEF HEALTH AND MEDICAL OFFICER (OCHMO)

MISSION STATEMENT

The Office of the Chief Health and Medical Officer (OCHMO) is responsible for policy and oversight of all health and medical activities at NASA - from medical treatment of the astronaut corps and human system interface of space missions, to the health and wellness of workers on the ground, sea, and air.

OFFICE WEBSITE - *https://www.nasa.gov/offices/ochmo/main/*

IMAGE 35.1

OFFICE OF THE CHIEF HEALTH AND MEDICAL OFFICER CORE FUNCTIONS

HEALTH AND MEDICAL TECHNICAL AUTHORITY (HMTA)
The Chief Health and Medical Officer is the Health and Medical Technical Authority for NASA.

POLICY AND OVERSIGHT
OCHMO develops health and medical policy and assesses adequacy of procedural requirements and standards as they apply to the human system. Provides oversight and quality assurance of all health, medical, and space crew/personnel performance matters that either arise in association with the execution of, or are embedded in, NASA programs or projects. Provides policy guidance and oversight of veterinary services and programs throughout NASA.

OCCUPATIONAL HEALTH
Oversees and implements NASA occupational medicine clinic operations and contract requirements, as well as wellness programs aimed at keeping the NASA workforce healthy and viable.

MEDICAL AND HEALTH EXPERTISE
Provides medical and health expertise in collaboration with Human Research Programs.

AGENCY INSTITUTION REVIEW BOARD
Acts as the Agency Institution Review Board approval official.

INDEPENDENT ASSESSMENT
Provides an independent assessment of medical and health technical standards and implementation.

OFFICE OF THE CHIEF HEALTH AND MEDICAL OFFICER ORGANIZATION

The Office of the Chief Health and Medical Officer is divided into two main divisions: Medical Policy and Ethics, and Health and Medical Systems. Under these two main umbrellas fall the Operational Space Medicine, the Chief Veterinary Officer, Bioethics, Occupational Medicine, Industrial Hygiene, and Aviation Medicine components.

The Chief Health and Medical Officer is also the Agency Health and Medical Technical Authority (HMTA) with responsibilities to ensure that health and medical policy, procedural requirements, and standards are addressed in program/project management when applicable and appropriate. HMTA provides independent oversight of all health, medical, and space crew/personnel performance matters that either arise in association with the execution of, or are embedded in, NASA programs or projects. Although most HMTA issues involve human space flight, issues occurring on other NASA flight and Research and Technology (R&T) programs/projects are covered by OHCMO areas of responsibility.

The organizational chart provides insight into the official roles and relationships within OHCMO.

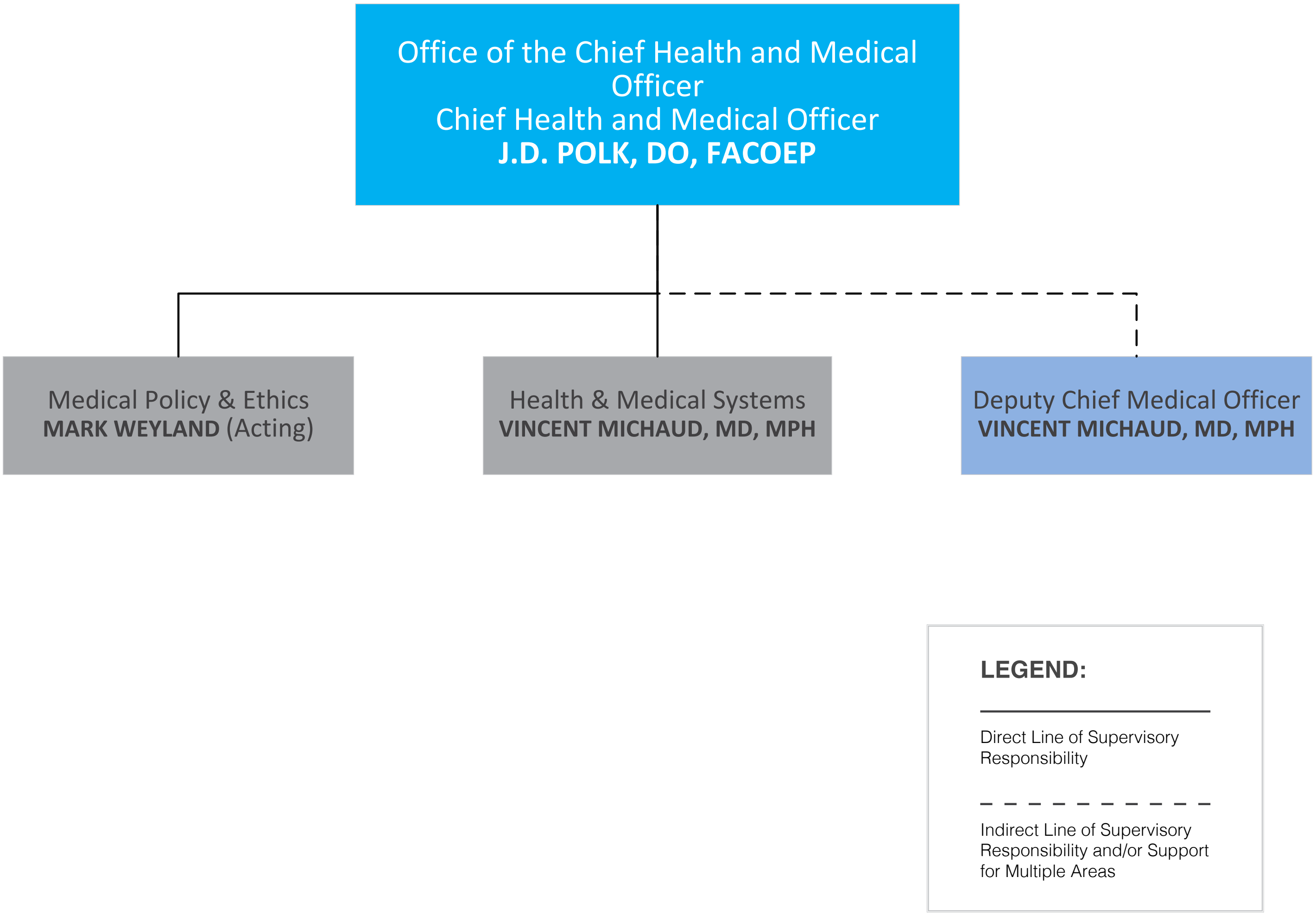


Figure 35.1 Office of the Chief Health and Medical Officer (OCHMO) Organization Chart

CHIEF HEALTH AND MEDICAL OFFICER
DR. D. POLK

DEPUTY CHIEF MEDICAL OFFICER
DR. VINCENT MICHAUD, MPH

Dr. Vincent Michaud serves as NASA's Deputy Chief Medical Officer and is responsible for the oversight of all health and medical activities at NASA, including medical aspects of all national and international NASA missions involving humans. He holds an M.D. degree from the University of Texas Southwestern Medical School in Dallas, and completed residencies in Aerospace Medicine and Occupational Medicine at the USAF School of Aerospace Medicine at Brooks AFB, Texas. A Fellow of the Aerospace Medical Association, he is certified by the American Board of Preventive Medicine (Aerospace and Occupational Medicine). He has extensive experience in the clinical practice of aerospace medicine and occupational medicine as well as in administrative medical management.

EXTENDED BIO - *https://www.nasa.gov/offices/ochmo/main/deputy_chmo_biography.html*

IMAGE 35.2

OFFICE OF THE CHIEF HEALTH AND MEDICAL OFFICER AT A GLANCE

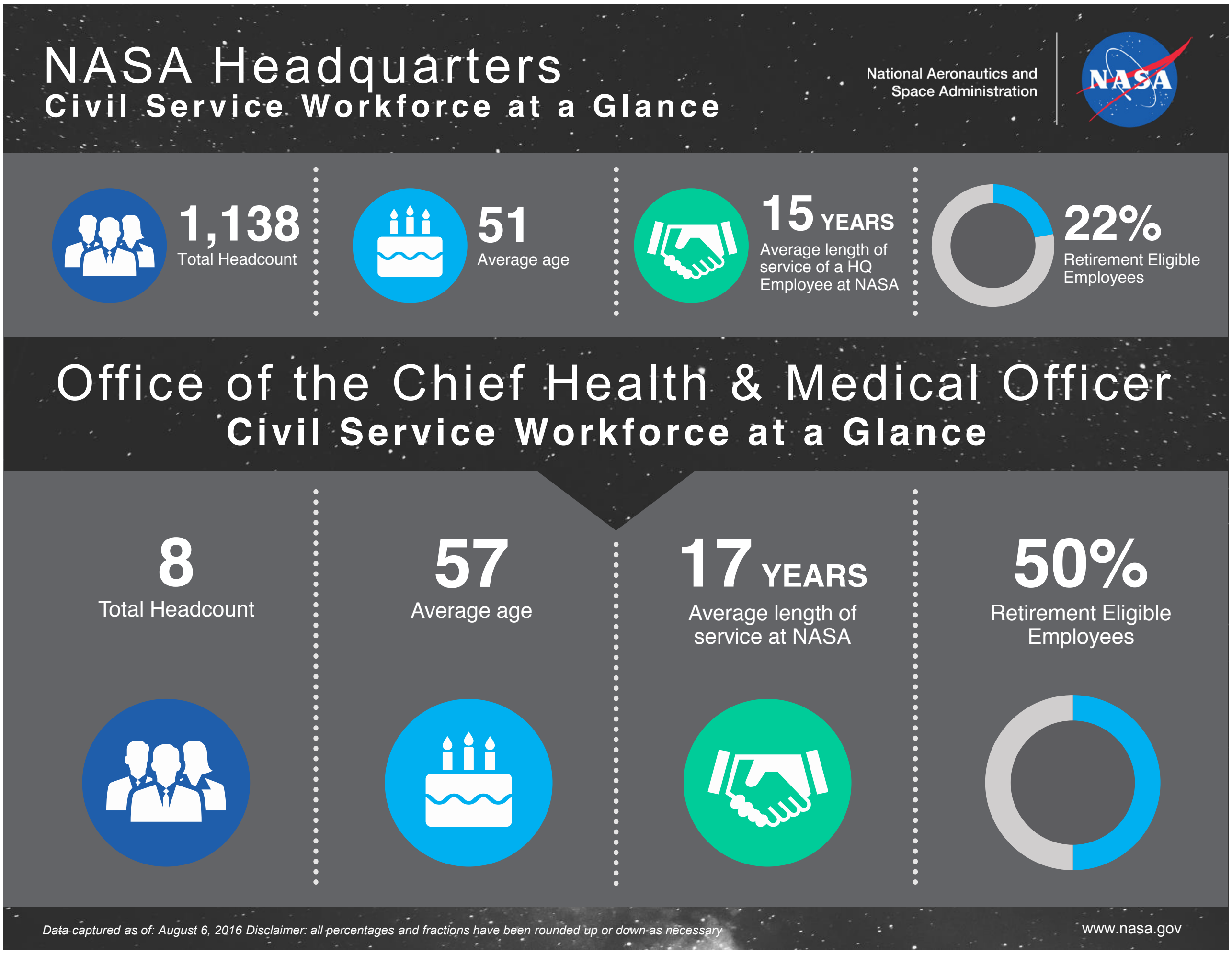


Figure 35.2 Office of the Chief Health and Medical Officer Workforce at a Glance

IMAGE 35.3

ASTRONAUT HEALTHCARE LEGISLATION

This new legislation would provide the NASA Administrator authority to allow the Agency to perform annual medical monitoring and provide diagnosis and treatment for active as well as former crewmembers throughout their lifetime for medical conditions, which are deemed by NASA to be associated with human spaceflight. Currently, NASA only has the authority to diagnose and treat active astronauts, and many of the effects of human spaceflight (vision changes, bone loss, cancer risk) have long lead times such that having this explicit authority allows for care of the astronauts who have dutifully exposed themselves to the risks, but also gather data to better inform future spaceflight health risks. The legislative proposal was approved by OMB and two briefings (House and Senate) have occurred on this topic area.

HEALTH AND MEDICAL TECHNICAL AUTHORITY (HMTA) REVIEW FOR NEW VEHICLES

It has been over 30 years since NASA has built and flown its own vehicle. To that end, the HMTA works to verify the requirements and implementation of vehicle design elements that impact the human system. The HMTA is working with the Orion Vehicle and the Commercial Spaceflight Vendors to ensure the safety and health requirements are incorporated into new vehicles.

INSTITUTE OF MEDICINE REVIEWS

The OCHMO utilizes the National Academies to review policies and strategies aimed at improving the outcomes, knowledge, surveillance, and ethical construct as it applies to human spaceflight. Independent assessments are utilized on an almost annual basis to ensure that the office is giving the best possible advice to the Agency. These reviews are then used (in addition to current policy and NASA strategic guidance) to formulate new directives and policy in order to ensure employees are being provided the best possible care and outcomes to the astronauts and the NASA employees.

ADDITIONAL RESOURCES

- WWW: Institute of Medicine Review of Astronaut Healthcare for Exploration Class Missions
- WWW: NASA Human Research Roadmap
- WWW: Institute of Medicine Review of NASA's Longitudinal Study of Astronaut Health
- Institute of Medicine Report: Health Standards for Long Duration and Exploration Spaceflight: Ethics Principles, Responsibilities, and Decision Framework

OFFICE OF THE CHIEF INFORMATION OFFICER (OCIO)

MISSION STATEMENT

The Office of the Chief Information Officer (OCIO) provides leadership, planning, policy direction, and oversight for the management of NASA information and all NASA information technology (IT) in accordance with the responsibilities required by the Clinger-Cohen Act of 1996, the Paperwork Reduction Act of 1995, the EGovernment Act of 2002, the Federal Information Security Management Act of 2002, the Privacy Act of 1974, the Federal Information Technology Acquisition Reform Act (FITARA) of 2014, and the Federal Information Security Modernization Act (FISMA) of 2014. The Chief Information Officer (CIO) is the principal advisor to the Administrator and other senior officials on matters pertaining to information technology, the NASA Enterprise Architecture, IT security, records management, paperwork reduction, and privacy.

OFFICE WEBSITE - *https://www.nasa.gov/offices/ocio/home/index.html*

IMAGE 36.1

OFFICE OF THE CHIEF INFORMATION OFFICER CORE FUNCTIONS

INFORMATION TECHNOLOGY AND SECURITY DIVISION (ITSD)

The ITSD develops, implements, and maintains security strategy, requirements, and policy that align NASA's enterprise security programs, investments, and capabilities by delivering enterprise security services to improve the Agency's information and information technology security posture.

CAPITAL PLANNING & GOVERNANCE (CP&G) DIVISION

The CP&G Division administers NASA's information resources for Agency IT spending, strategic planning, and establishing IT governance and policy guidelines for evaluating Agency IT.

ENTERPRISE SERVICE AND INTEGRATION DIVISION (ES&I)

The ES&I Division manages the portfolios for all enterprise IT services and provides integration of enterprise services to facilitate use of a core suite of collaboration tools and content management systems.

TECHNOLOGY & INNOVATION (T&I) DIVISION

The T&I Division provides technology infusion, data management and interoperability, and open innovation to meet the White House and Office of Management and Budget (OMB) strategic goals of Open Data and Open Government.

OFFICE OF THE CHIEF INFORMATION OFFICER ORGANIZATION

The OCIO is an Agency-level organization, composed of four divisions and a small front office staff, housed at NASA HQ, in Washington, DC. Eight Center CIOs, located throughout the country, report to the NASA CIO and are shown on the organization chart. The five OCIO divisions (Front Office, IT Security, Enterprise Services, Capital Planning and Governance, and IT Technology and Innovation) have the following Agency responsibilities: Cyber Security, IT Technology and Innovation, Data Management, including Open Data and data access, Digital Engagement, Technology Infusion, IT Governance (including policy development), IT Resource Management, IT Enterprise Architecture, IT Services for Communication, Computing, End User experiences, Information Management, Enterprise Service Support, Enterprise Applications, and Web functionality.

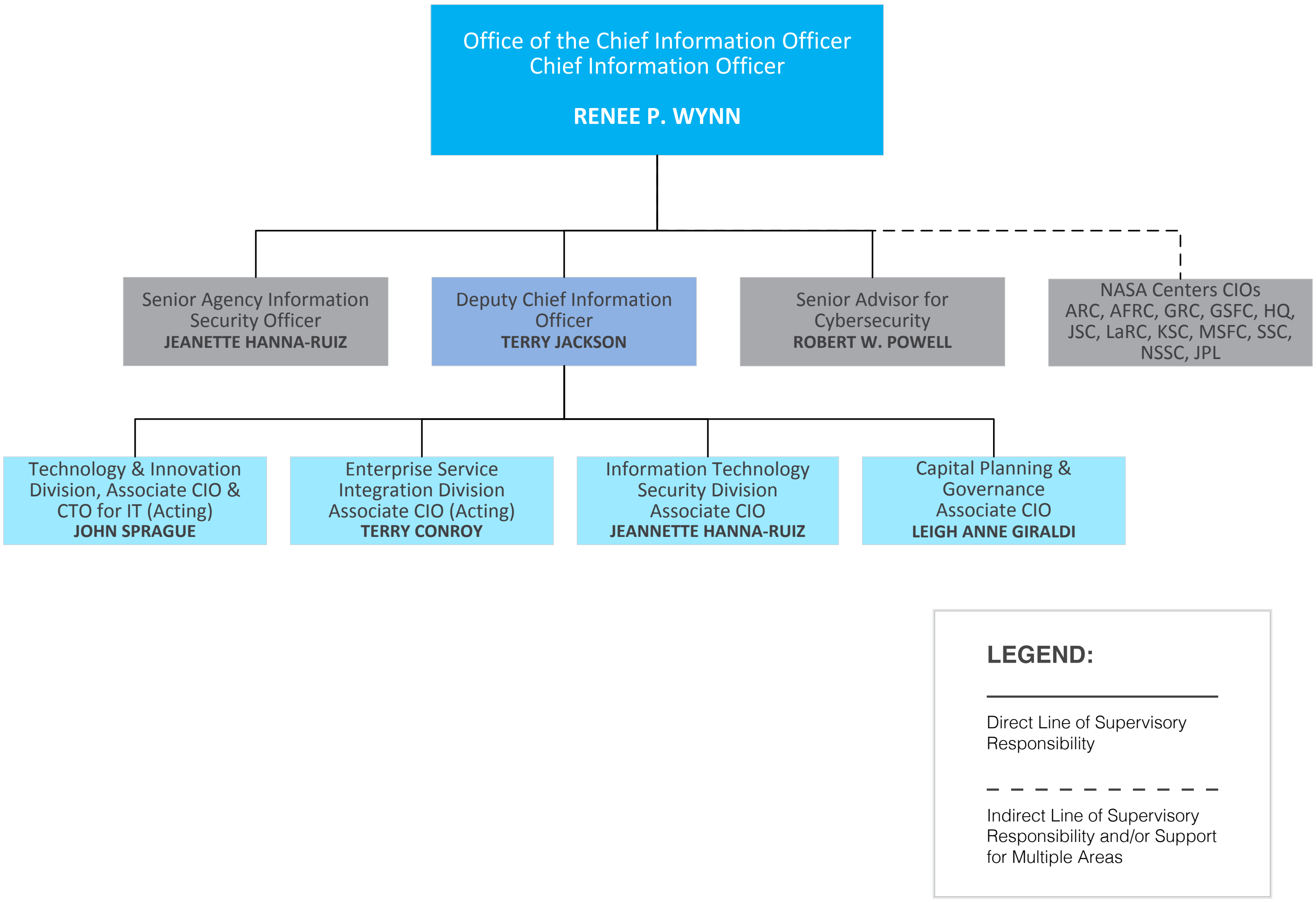


Figure 36.1 Office of the Chief Information Officer (OCIO) Organization Chart

CHIEF INFORMATION OFFICER

MS. RENEE P. WYNN

Renee Wynn became the NASA CIO in September 2015. She came to NASA from the Environmental Protection Agency where she served as the Acting Assistant Administrator for the Office of Environmental Information since July 2013. Ms. Wynn was with the EPA for more than 25 years. Ms. Wynn managed program administration for science, information management, and international programs; regulatory management; budget formulation and execution; contracts, grants and interagency agreements; long term strategic planning and analyses; and environmental and administrative policy. She holds a Bachelor of Arts in Economics from DePauw University, Indiana.

EXTENDED BIO - *http://www.nasa.gov/offices/ocio/home/cio.html*

DEPUTY CHIEF INFORMATION OFFICER

MR. TERRY D. JACKSON

Terry Jackson is the NASA Deputy Chief Information Officer. Mr. Jackson has over 36 years of IT experience, with 26 years at NASA. He has experience in managing senior level staffs, leading a variety of small and large scale programs and projects, establishing organizations, and supporting mission and mission support organizations. Prior to his role as Deputy CIO, he served as the Associate CIO for Enterprise Services and Integration for two years. He was responsible for ensuring NASA enterprise IT services enabled the NASA mission and were economical, secure and integrated. His areas of responsibilities included End-User Services, Communications Services, Web Services, Computing Systems Services, Enterprise Applications, Information Management, and Enterprise Service Desk Services.

IMAGE 36.2

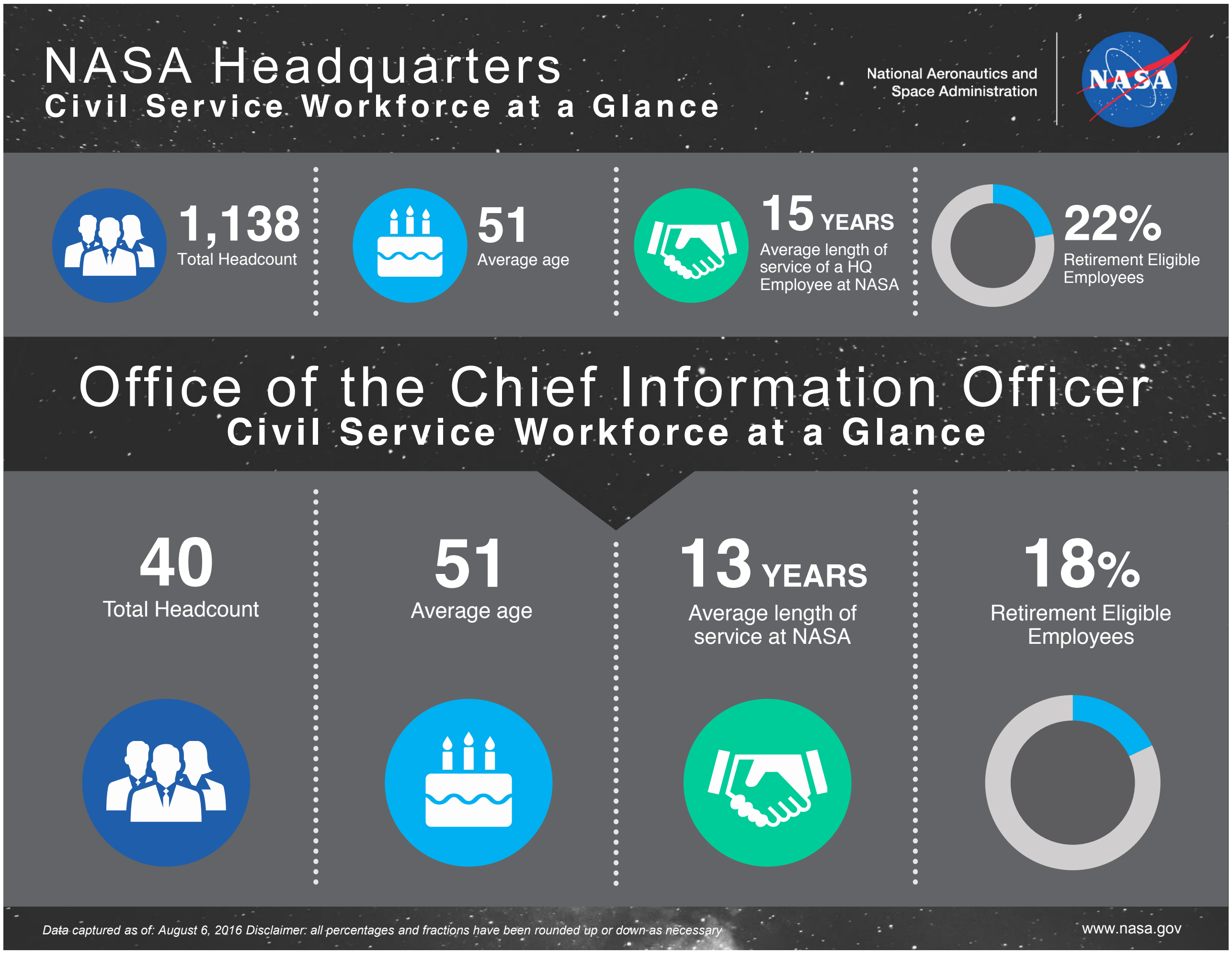


Figure 36.2 Office of the Chief Information Officer Workforce at a Glance

IMAGE 36.3

CONTINUOUS DIAGNOSTICS AND MITIGATION (CDM)

The Office of Management and Budget identified continuous monitoring of Federal IT networks as one of 14 Cross-Agency Priority (CAP) goals, established in accordance with the Government Performance and Results Modernization Act, to improve the federal IT security posture and improve the federal cyber environment. To support Federal departments and agencies in meeting the CAP goal, Department of Homeland Security (DHS) established the CDM Program, an executive branch implementation approach consistent with the Information System Continuous Monitoring methodology. NASA OCIO established the NASA CDM project team to coordinate and manage the NASA CDM program, work closely with DHS to integrate CDM with existing NASA capabilities, develop internal NASA dashboards, and provide ongoing operation/maintenance of CDM tools. The NASA CDM team coordinates requirements and design for the installation of the IT security CDM tools within the NASA infrastructure, vastly improving the NASA cyber infrastructure.

IT INFRASTRUCTURE TRANSITION

NASA is actively pursuing an infrastructure transition to focus on information-centric security; intelligent network zoning; and internal and external border protection. Success elements include: Enterprise Border Protection (EB-PRO) to deploy network filtering and security devices between NASA's private internal networks and non-NASA networks that are external to NASA's Trusted Internet Connection locations. Other components include the Enterprise Internal Border and Network Access Control (EIB-NAC) to implement a NAC solution that identifies, validates, and places network-connecting endpoints and users into network zones commensurate with applicable security policy; and Mobile Device Management (MDM) to establish base requirements, proposed guidelines, and procedures for use with both Government issued and personal mobile devices to access specific NASA resources; to implement an Agency solution to register devices, deliver PIV-derived credentials, and support secure app access. The result will be an integrated, secure NASA IT operating environment, allowing access while ensuring cyber protections.

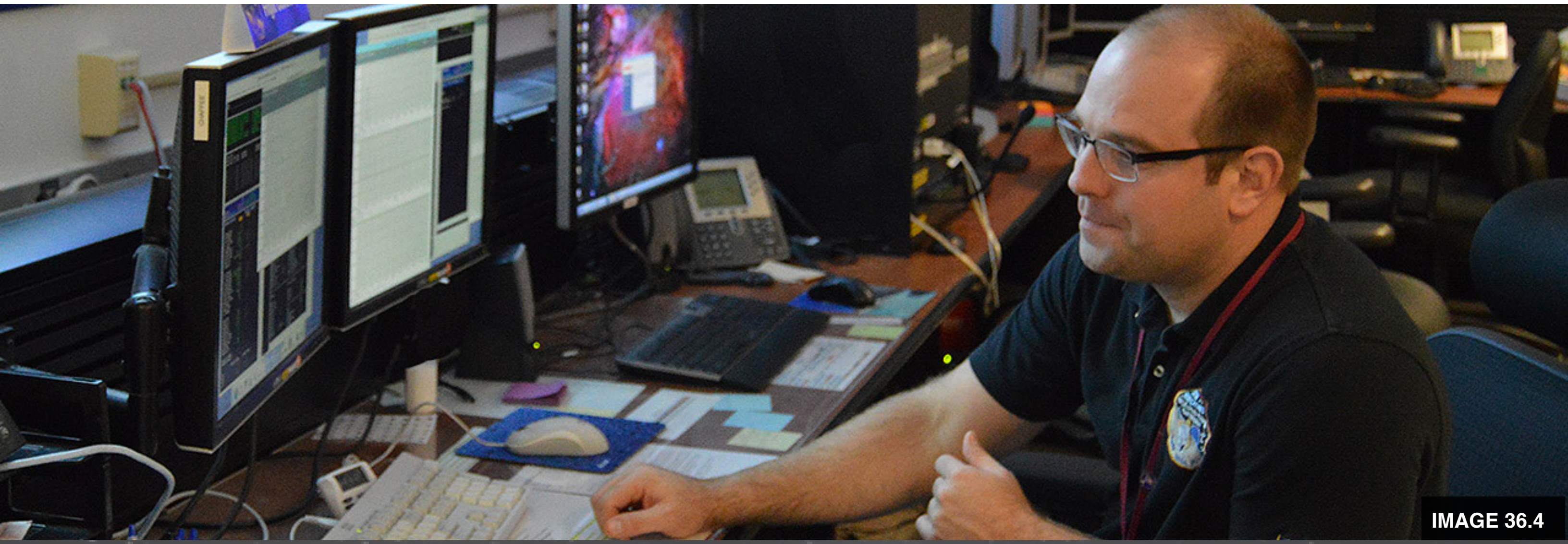


IMAGE 36.4

BUSINESS SERVICES ASSESSMENT (BSA)

Through the execution of the BSA, NASA is defining the health of each business service area, identifying opportunities for optimization, and developing risk-informed recommendations to establish a more efficient operating model that maintains a minimum set of capabilities and meets current and future mission needs. The BSA for IT establishes a more efficient Agency information technology operating model that maintains a minimum set of capabilities and meets current and future mission needs. The findings from the BSA for IT identified challenges and associated improvements in 7 IT areas: Roles and Responsibilities, Governance, Security, Communications, Collaboration, Data Centers, and Workstations. The OCIO is executing a detailed plan to fulfill the improvements, including organizational changes to distinguish IT responsibilities, IT governance framework changes supporting CIO influence and visibility across NASA IT resources, a set of Agency collaboration tools, increased use of enterprise desktop support, an Agency data center architecture to guide future investments, and an IT security risk framework and architecture.

DATA MANAGEMENT

NASA is working a multitude of Data Analytics/Deep Learning, Search Analytics, Tagging, Financial Analytics, Data Centric Model, APIs, and Data Integration prototypes. There is special emphasis on creating micro services that the Mission Directorates and Agency Support Organizations can use to further NASA's mission. For example, the NASA OCIO Data Management Team has completed a series of data visualizations of financial data within the OCIO and Office of the Chief Financial Officer areas. Working with the NASA Security Operations Center (SOC), two prototypes are nearing completion to help solve data tagging and network logging needs. The benefit to NASA and the public will be an accessibility to historic scientific and engineering data which promotes NASA's core mission of sharing and improving the Nation's capabilities.

ADDITIONAL RESOURCES

- www [Open NASA]
- www [NASA Data Portal]
- www [NASA Open Source Software]
- www [NASA APIs]
- www [Enterprise Service and Integration (ES&I) Division]

OFFICE OF THE CHIEF TECHNOLOGIST (OCT)

MISSION STATEMENT

The Chief Technologist is the NASA Administrator's principal advisor and advocate on matters concerning Agency-wide technology policy and programs. The office conducts annual reviews and assessments of technology investments across the Agency and facilitates strategic technology integration and alignment with NASA's Strategic Plan across the Agency's technology driven portfolio. The office also serves as an advocate for cultural change toward creativity and innovation at NASA Centers, particularly in regard to workforce development. The office identifies innovative technology partnerships and communicates societal impact of NASA technology investments within and outside the Agency. The office employs principles that encourage innovative partnerships, technology use for societal benefit, and commercialization; helping to ensure NASA technology is transferred into viable products and services that benefit our lives here on Earth, right now.

OFFICE WEBSITE - *www.nasa.gov/offices/oct/home/*

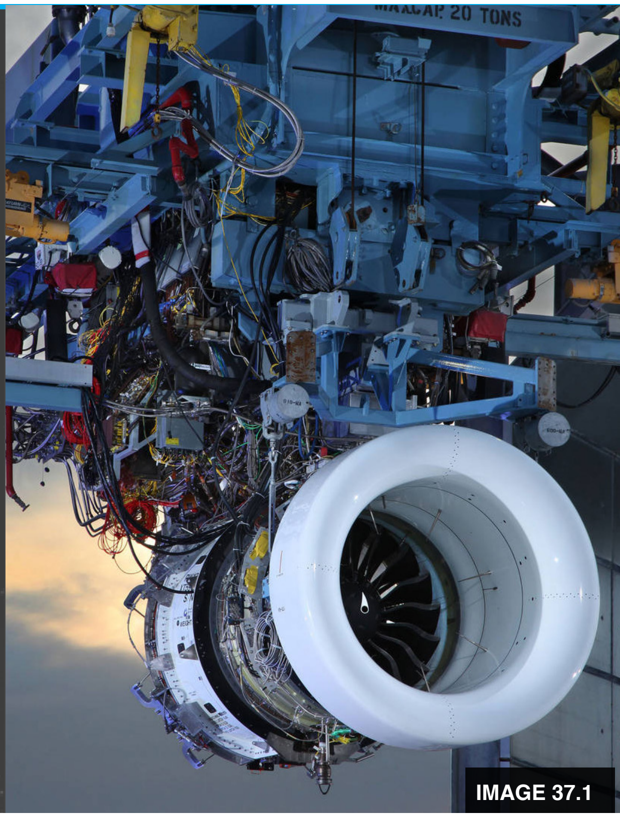


IMAGE 37.1

OFFICE OF THE CHIEF TECHNOLOGIST CORE FUNCTIONS

TECHNOLOGY LEADERSHIPS AND INTEGRATED AND STRATEGIC TECHNOLOGY PORTFOLIO MANAGEMENT

- Principal advisor and advocate on matters concerning Agency-wide technology policy and programs.
- Provides leadership, policy direction, Agency-level strategy and priorities, technology portfolio assessment, and coordination for NASA mission-focused technology activities.
- Develops and implements strategic plans across the mission directorates that address technology goals, objectives, technical challenges, and investment.
- Conduct annual Agency level technology portfolio analysis.
- Manages the NASA Technology Executive Council (NTEC) and the Center Technology Council (CTC).

OFFICE OF THE CHIEF TECHNOLOGIST CORE FUNCTIONS

AGENCY TECHNOLOGY AMBASSADOR

- Engages the technology community including other Government agencies, industry, academia, and advisory groups to identify needs and recommend priorities that NASA should pursue consistent with National Space Policy, NASA's mission, and national needs.
- Documents and communicates the benefits of NASA technology investments.
- Serves as the Administrator's NASA technology represevntative to the international community, as appropriate.
- Adocates for NASA research and technology programs through coordination with other Government agencies, academia, and the commercial aerospace industry.
- Maintains a streamlined technology roadmap to maintain awareness of technology activities worldwide that have potential impact on NASA missions.

MANAGE NASA'S INNOVATION FRAMEWORK

- Works with Headquarters Offices and Center Directors to implement NASA's Innovation Framework to enhance creativity and innovation, particularly in regard to workforce development.

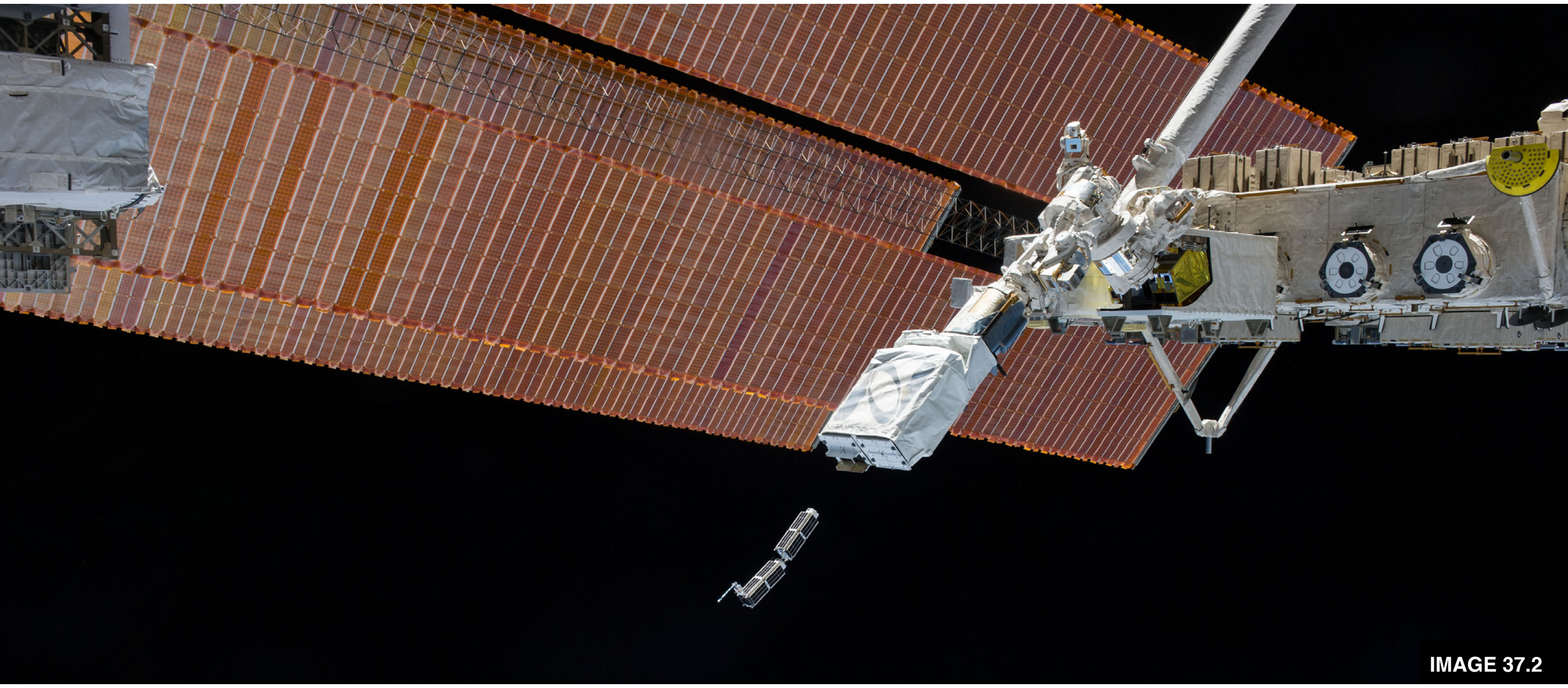


IMAGE 37.2

OFFICE OF THE CHIEF TECHNOLOGIST ORGANIZATION

The Office of the Chief Technologist consists of a front office staff (Chief Technologist, Deputy Chief Technologist, Executive Officer, Administrative Assistant) and two teams -- the Strategic Integration and Innovation teams.

The Chief Technologist serves as a member of the NASA Executive Council, the Mission Support Council (extended), the Program Management Council, and the Senior Management Council. The Chief Technologist chairs the NASA Technology Executive Council (NTEC) and the Center Technology Council, which includes the NASA Center Chief Technologists.

The Chief Technologist serves under an Intergovernmental Personnel Act (IPA) appointment, while the Deputy Chief Technologist is a career member of the NASA Senior Executive Service. As the career senior civil servant, the Deputy Chief Technologist provides supervisory and management oversight of the office and staff and serves as the Acting Chief Technologist when the Chief Technologist position is vacant.

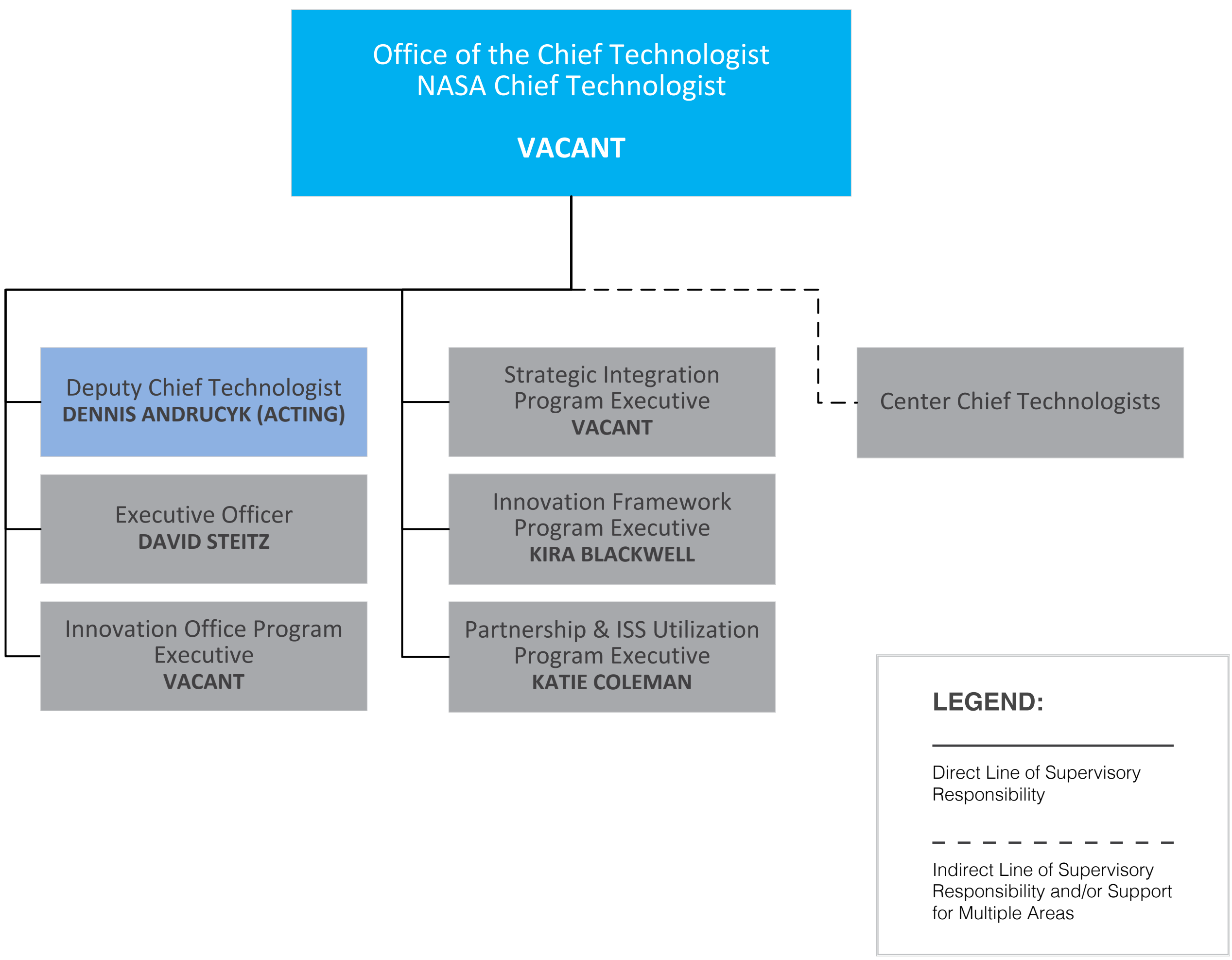


Figure 37.1 Office of the Chief Technologist (OCT) Organization Chart

NASA CHIEF TECHNOLOGIST

VACANT

DEPUTY CHIEF TECHNOLOGIST

DENNIS ANDRUCYK (ACTING)

Dennis Andrucyk is the Acting Deputy Chief Technologist as well as the Deputy Associate Administrator of the Space Technology Mission Directorate (STMD). Andrucyk manages day-to-day operations of OCT and STMD. Prior to joining NASA HQ, Andrucyk held many positions at NASA's Goddard Space Flight Center. He was Director of the Applied Engineering & Technology Directorate, serving as Director of Engineering, Deputy Director of Engineering, Chief of the Software Engineering Division, and Chief of the Mission Engineering and Systems Analysis Division. He also served as Goddard's Chief Technologist and as the Associate Chief of the Electrical Engineering Division.

EXTENDED BIO - *http://www.nasa.gov/directorates/spacetech/about_us/bios/andrucyk_bio.html*

IMAGE 37.3

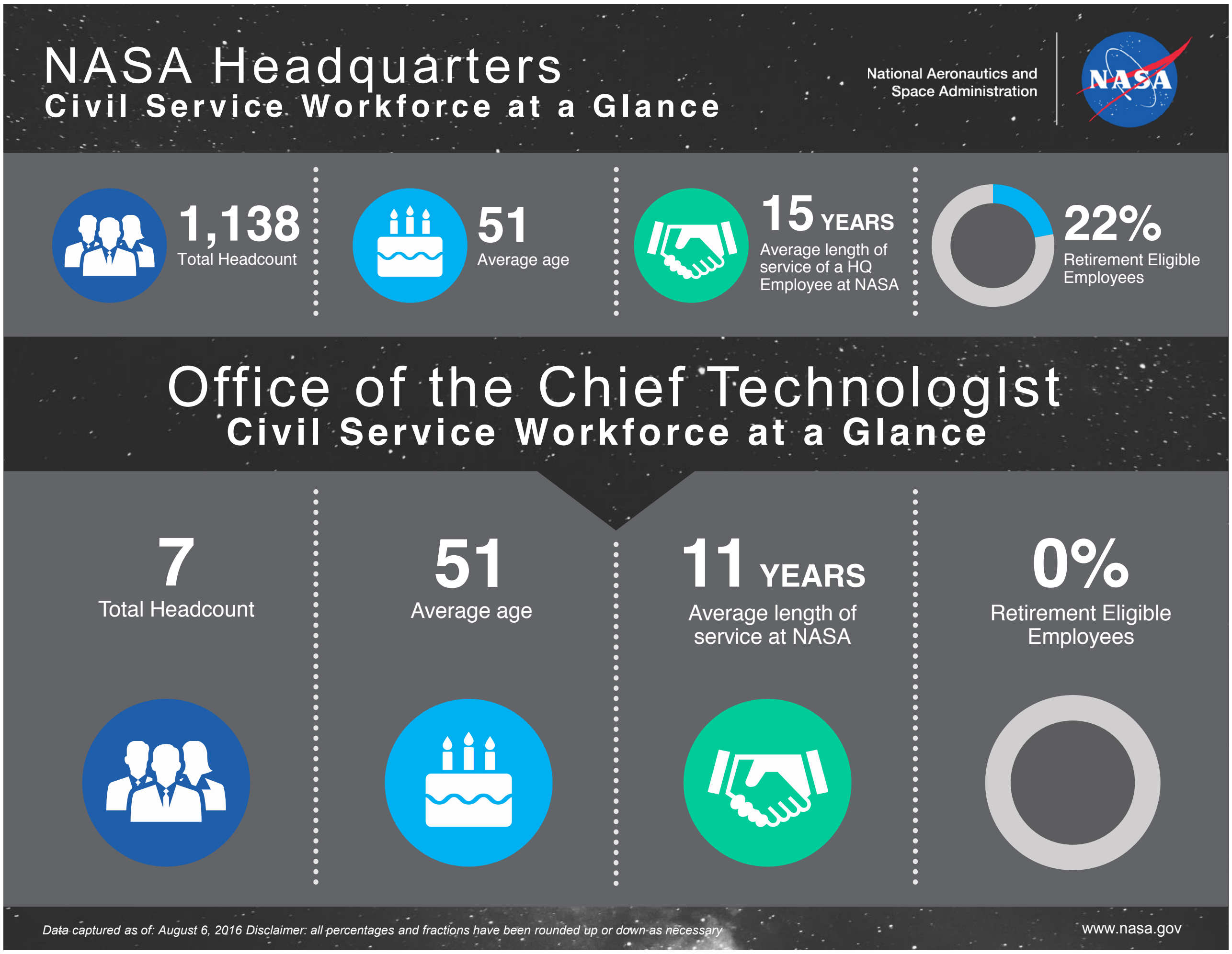


Figure 37.2 Office of the Chief Technologist Workforce at a Glance

IMAGE 37.4

TECHNOLOGY ROADMAPS

In 2011 OCT created and has since updated NASA's Technology Roadmaps, recently receiving a review of the 2015 Roadmaps from the National Academies. The Technology Roadmaps have helped NASA to inventory and prioritize past and current investments in technologies that will lead to the new knowledge and capabilities needed to enable future missions while benefiting America's new technology economy.

STRATEGIC TECHNOLOGY INVESTMENT PLAN (STIP)

In 2014 OCT created and updates the NASA STIP every two years. The STIP serves as an informative document for Agency-level budget planning that takes into account the technology work NASA has been conducting, as identified in the Technology Roadmaps, and the prioritized, known future technology needs necessary for the Agency to meet mission goals. NASA is in the process of updating the STIP, with a new version available this fall. NASA has completed a draft review of the technology development prioritization, and is validating the latest version of the plan.

ENGAGEMENT OF TECHNOLOGY COMMUNITY

The NASA Chief Technologist chairs and conducts NASA Technology Executive Council meetings. NASA has held three NTEC meetings in FY2016 to discuss the STIP and other technology matters. OCT also annually evaluates the Agency technology portfolio and makes recommendations during the budget process. The Chief Technologist represents NASA at the Space Partnership Science and Technology Forum with the Air Force and the intelligence community. OCT regularly organizes Technical Interchange Meetings with the Department of Defense and other federal agencies to share information on technology investments and needs of mutual interest to NASA and partner organizations.

INNOVATION

OCT advises the Office of the Administrator on strategies for fostering innovation across the Agency and harnessing innovation approaches from both inside and outside NASA. As part of this activity, OCT is supporting the Office of the Administrator in developing Agency-level frameworks to define innovation, share examples of innovation best practices across the Agency and look for approaches to scale promising practices across the Agency, where appropriate. OCT serves as a resource for Mission Directorates, Centers, and organizations across the Agency to provide thought leadership and support on innovation activities. One of the main approaches that OCT takes to achieve this is coordinating with the Center Chief Technologist offices to provide them with opportunities for training, networking, and joining innovation projects. OCT serves as an incubator for innovation approaches within NASA that have the potential to become programs within the Mission Directorates or other offices.

! ADDITIONAL RESOURCES

WWW [NASA Space Technology Roadmaps]

WWW [NASA Strategic Space Technology Investment Plan]

OFFICE OF THE CHIEF SCIENTIST (OCS)

MISSION STATEMENT

The Office of the Chief Scientist (OCS) advises and advocates for the NASA Administrator on matters concerning Agency-wide science policy and programs. The OCS serves as a primary external interface regarding science issues and results on behalf of the Administrator. The OCS encourages and fosters science integration and cooperation across the Agency and provides oversight to assure that NASA funds only the most exemplary and meritorious science to enable NASA to achieve its mission.

OFFICE WEBSITE - *http://www.nasa.gov/offices/ocs/*

IMAGE 38.1

OFFICE OF THE CHIEF SCIENTIST CORE FUNCTIONS

ASSESSMENT
Provides independent assessment and advice to the Administrator on matters related to NASA science and represents the Administrator to the National Advisory Council (NAC) Science Committee, the National Academy of Sciences, other science advisory bodies, and the international community, as appropriate.

DEVELOPMENT
Leads the development of Agency science strategy and ensures that NASA's overarching Strategic Plan properly incorporates science goals and objectives.

ANALYSIS
Provides independent portfolio analysis of significant science activities, as appropriate, and performs scientific, technical, programmatic, and/or policy reviews to assure that NASA science programs are of the highest scientific and technologic merit and integrity.

INTEGRATION
Encourages and fosters science integration and cooperation across the Agency, including the Mission Directorates and the Centers. Works with the Center Directors to promote scientific vitality and innovation at the Centers.

OFFICE OF THE CHIEF SCIENTIST ORGANIZATION

The Chief Scientist serves as an active member of many councils, boards, and committees across the Agency, including, but not limited to NASA's Executive Council, Mission Support Council (extended), Program Management Council, and Senior Management Council. Within the OCS is the Agency's Life Sciences Technical Capability Leader, who provides expert advice to ensure proper alignment across Missions and Centers consistent with the Agency and capability advancement needs. OCS also provides support and guidance to the Space Life and Physical Sciences Research and Applications Division in the Human Exploration and Operations (HEO) Mission Directorate to ensure its alignment with Agency science priorities and to increase the visibility of the HEO research portfolio at the Agency level.

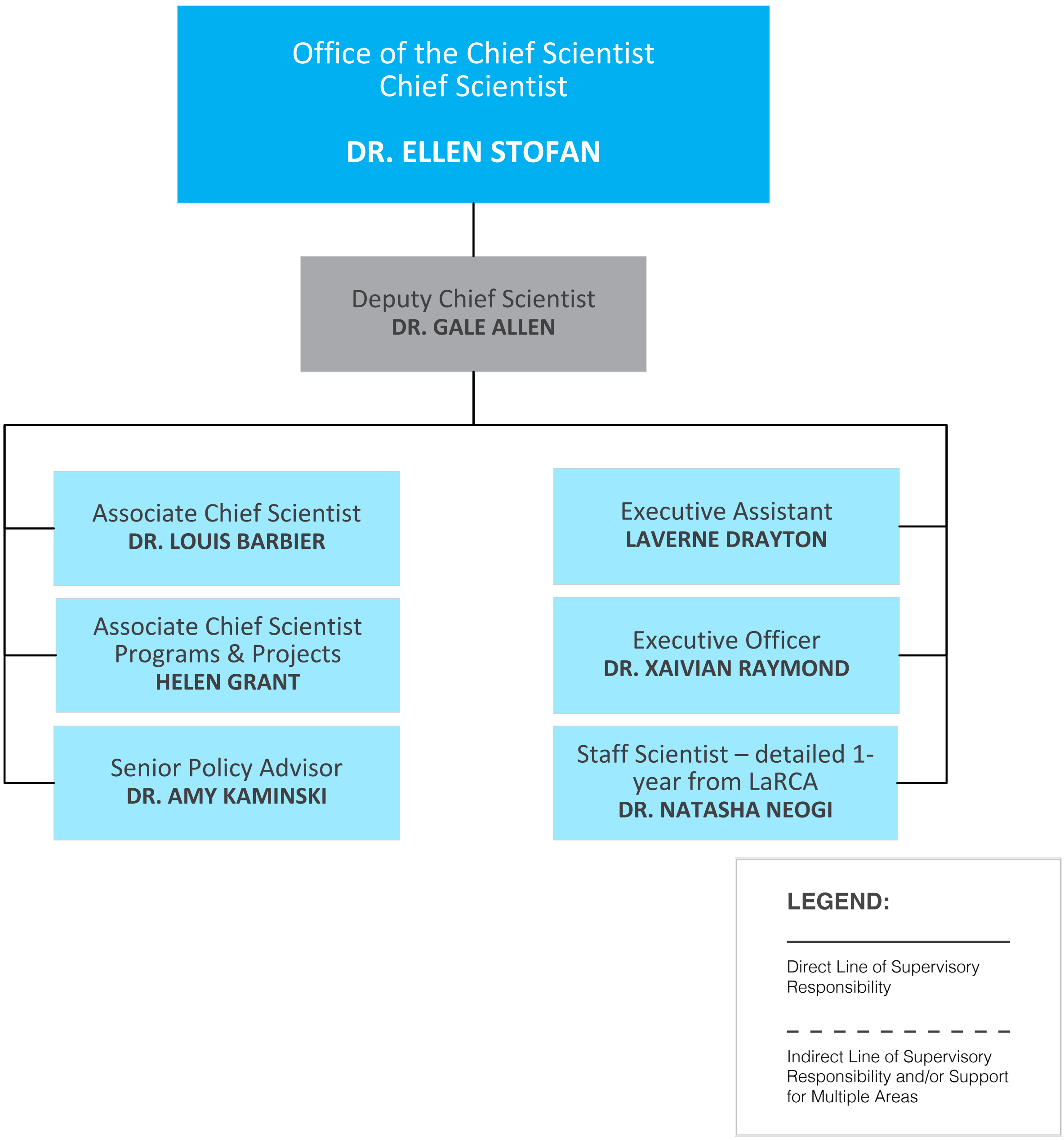


Figure 38.1 Office of the Chief Scientist (OCS) Organization Chart

CHIEF SCIENTIST
DR. ELLEN STOFAN

Dr. Ellen Stofan was appointed NASA Chief Scientist in 2013, serving as principal advisor to the NASA Administrator on the Agency's science programs and science-related strategic planning and investments. From 1991 through 2000, she held a number of senior scientist positions at NASA's Jet Propulsion Laboratory. Her research has focused on the geology of Venus, Mars, Titan, and Earth. Stofan is an associate member of the Cassini Radar Team and was a co-investigator on the Mars Express Mission's MARSIS sounder. She was previously an honorary professor in the Department of Earth Sciences at University College London. Stofan was also principal investigator on the Titan Mare Explorer, a proposed mission to send a floating lander to a sea on Titan.

EXTENDED BIO - *https://www.nasa.gov/offices/ocs/stofan_bio.html*

DEPUTY CHIEF SCIENTIST
DR. GALE ALLEN

Dr. Gale Allen is currently serving as NASA's Deputy Chief Scientist at the Agency's headquarters. Dr. Allen began her NASA career at the Kennedy Space Center as Chief of the Materials and Chemistry Branch where she led the effort in developing ozone depleting alternatives for precision cleaning of flight and ground hardware. She has also served as NASA's Associate Director of Technology Programs and Commercialization, Deputy for the Bioastronautics Research Program, Deputy for the Human Systems Research and Technology Program, and Director, Strategic Integration and Management.

EXTENDED BIO - *http://www.iafastro.org/biographie/gale-allen/*

IMAGE 38.2

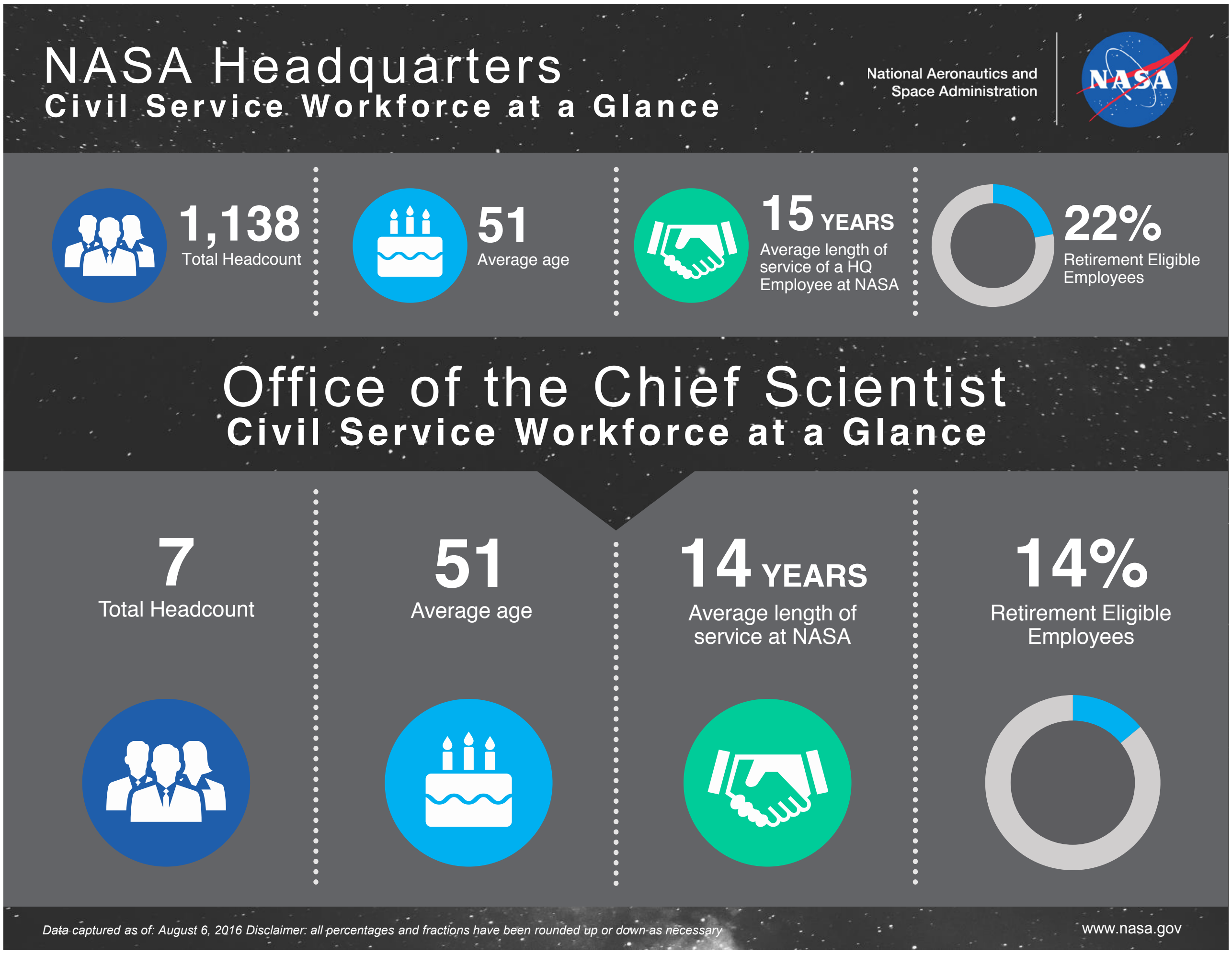


Figure 38.2 Office of the Chief Scientist Workforce at a Glance

IMAGE 38.3

INTERNATIONAL SPACE STATION (ISS) UTILIZATION

The Chief Scientist continues to prioritize ISS utilization for science, technology, and microgravity research activities on the ISS through 2024. Utilize the ISS to validate many of the capabilities needed to maintain a healthy and productive crew in deep space. Current research is being conducted to improve the understanding of how humans adapt and function during long-duration space flights.

EXPANSION OF KNOWLEDGE AND HUMAN ACTIVITY INTO THE SOLAR SYSTEM

NASA is extending robotic and human presence into the solar system through a strategy that advances the capability to operate at increasingly farther distances from Earth. The Chief Scientist is working with Agency leadership on developing a CIS-Lunar strategy that would expand our reach beyond low Earth Orbit (LEO) and advance NASA's scientific knowledge and technological base. NASA and its partners will use this proving ground as a "test bed" for deep-space operations by decreasing reliance on Earth and gaining the knowledge and systems needed for reaching the ultimate goal of getting to the surface of Mars. The Chief Scientist is interfacing with the external community (various backgrounds, domestic and international) to encourage collaboration and partnerships. NASA would like to leverage the capabilities of interested parties to develop technologies, systems, and missions to meet individual objectives.

LOW EARTH ORBIT (LEO) COMMERCIALIZATION

NASA's objective is to transform management, development, operations, and research in LEO from a primarily government-driven enterprise to a private industry-driven commercial market with private supply and private and government demand. The Chief Scientist is working with Agency leadership to identify opportunities to increase commercialization in LEO. The ISS plays a key role for emerging commercial markets in LEO. Commercial partners, who are maturing their business models and technical approaches by providing critical services for the ISS, will be essential to enabling deep-space NASA missions.

SCIENTIST FUNDING MODEL

The Chief Scientist is working to implement a consistent funding model for civil service scientists across the Agency that will address hiring of scientists, satisfaction and retention of early career scientists, and increasing the productivity of the scientific staff while maintaining the quality of NASA research.

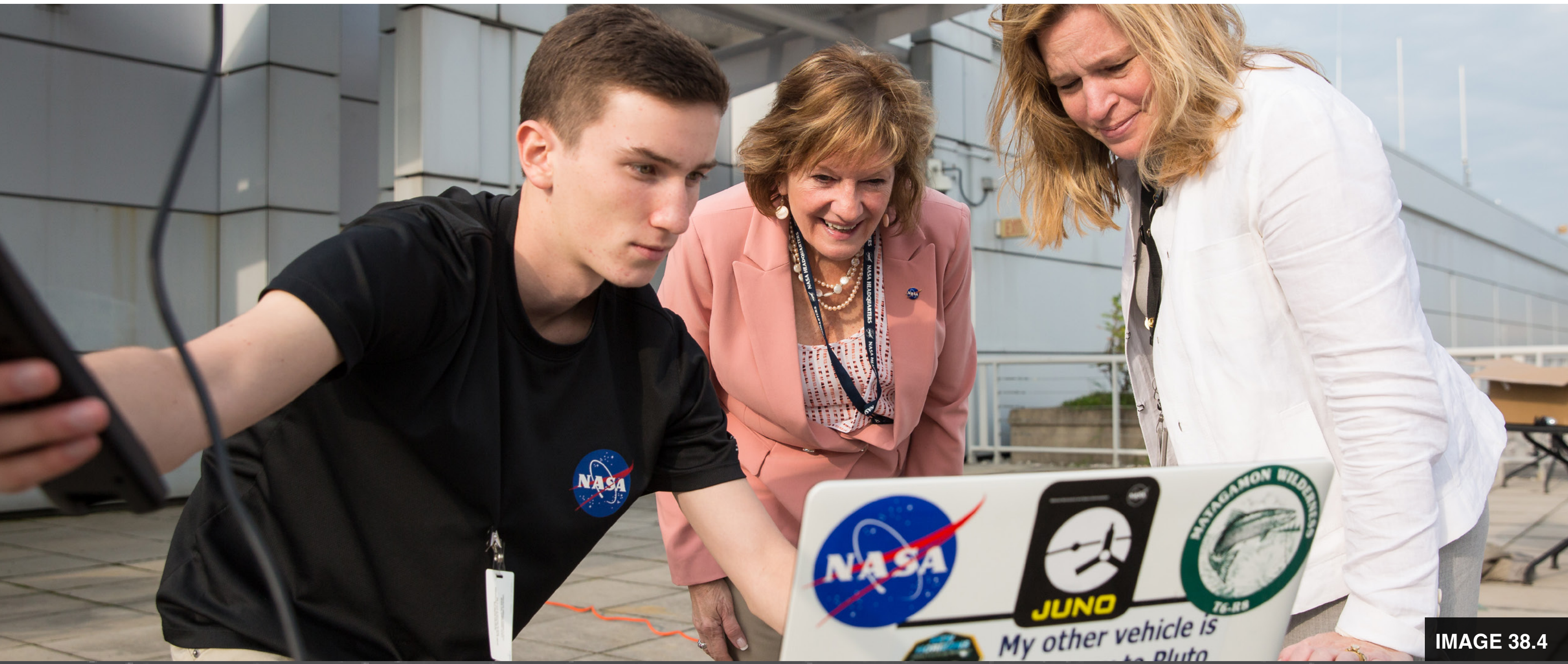


IMAGE 38.4

OFFICE OF THE GENERAL COUNSEL (OGC)

MISSION STATEMENT

The General Counsel establishes Agency-wide legal policy; provides Agency-level legal advice, counseling, and functional guidance; ensures the appropriateness of legal actions and activities Agency-wide; and provides binding formal legal opinions on Agency matters. With respect to legal matters, the General Counsel further ensures consistency of approach and eliminates duplication of functional support activities through agile, evolutionary, and intentional collaboration, centralization, and/or consolidation of functions among and within OGC legal practice groups, Center Chief Counsel Offices, and independent NASA entities such as the Federally Funded Research and Development Center (FFRDC) Jet Propulsion Laboratory (JPL) and the NASA Shared Services Center (NSSC).

OFFICE WEBSITE - *http://www.nasa.gov/offices/ogc/index.html*

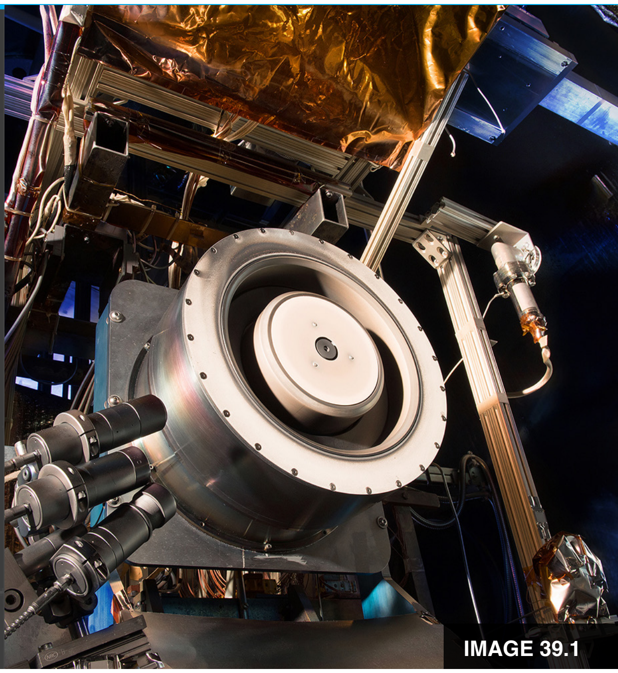


IMAGE 39.1

OFFICE OF THE GENERAL COUNSEL CORE FUNCTIONS

TRADITIONAL LEGAL SERVICES
Provide classic legal services including legal interpretation of relevant authorities, representing the Agency in various legal proceedings, providing legal representation for NASA in Agency negotiations, handling claims against the Agency, and executing appropriate releases from liability.

LEGAL ADVICE AND COUNSELING
Advise and counsel the Administrator, Senior Leadership, and Agency clients to proactively issue-spot, problem-solve, and guide our innovative clients throughout their programs' lifecycles thereby ensuring that Agency activities are conducted in accordance with all statutory and regulatory requirements.

LEGAL POLICY AND GUIDANCE
Administer policy and guidance relating to the use of various transactional legal authorities, including NASA's specific "other transactions" authority.

LEGAL COMMUNITY LEADERSHIP
Define the legal community's approach to executing NASA's Strategic Plan. In concurrence with Center Directors, hire and assess each Center's principal legal official. Provide legal subject-matter expertise and guidance to Center attorneys, which includes incorporating industry best-practices to develop an information-sharing system to enable Agency-wide access to legal work product.

LEGAL PROGRAM ADMINISTRATION
Administer the following programs: NASA Intellectual Property Law Program, including the Inventions and Contributions Board, Acquisition Integrity Program, and Ethics Program, which includes the Designated Agency Ethics Official.

OFFICE OF THE GENERAL COUNSEL ORGANIZATION

The Office of the General Counsel (OGC) is organized into a front office, four groups, and the Directorate Lead Counsel (DLC) initiative:

The Commercial and Intellectual Property Law Group handles non-procurement Partnership Agreements, intellectual property and licensing, technical data and computer software, and the Inventions and Contributions Board.

The Contracts Acquisition Integrity Law Group handles contracts, grants, and cooperative agreements. The Acquisition Integrity Program (AIP) handles legal issues regarding procurement fraud and related irregularities, remedies coordination, and suspension and debarment.

The General Law Group handles ethics, personnel, fiscal, environmental, information, and safety and security law, as well as legislation and areas not specifically assigned to one of the other divisions.

The International Law Group advises on international law (including space law), domestic law impacting international cooperation, international agreements, multilateral legal organizations, telecommunications, export control, and national security.

Directorate Lead Counsel (DLC) are experienced senior attorneys, from both Headquarters and Centers, assigned to career development positions as "embedded" assets, for periods of 12-18 months, to Mission Directorates, Headquarters Offices, or other NASA entities by agreement between the host entity and the General Counsel.

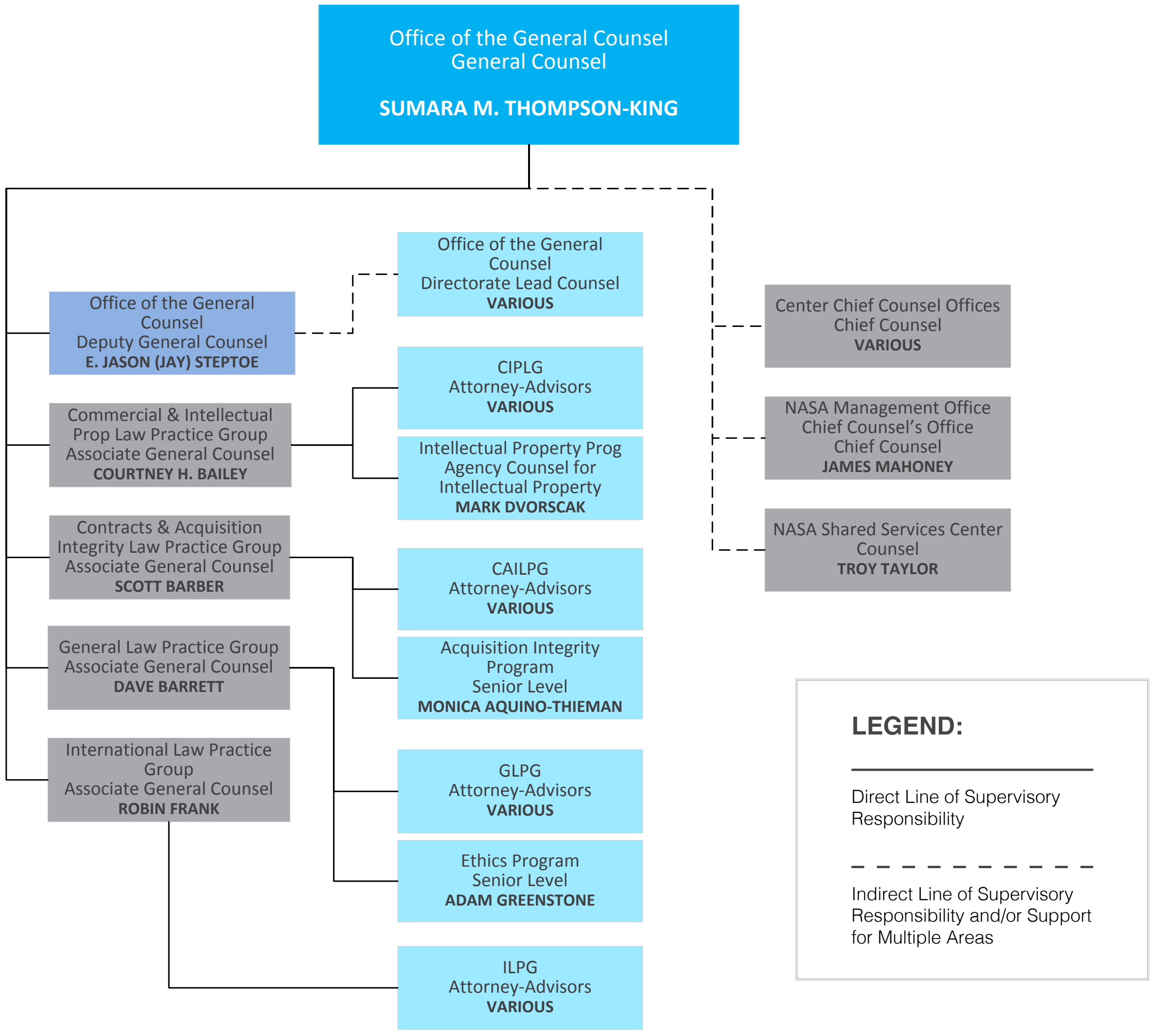


Figure 39.1 Office of the General Counsel (OGC) Organization Chart

GENERAL COUNSEL
MS. SUMARA M. THOMPSON-KING

Sumara M. Thompson-King is the General Counsel at NASA. She provides advice and counsel to NASA's Administrator and senior officials on a range of legal matters, and leads the Agency's legal team at Headquarters and its field Centers. Prior to her current position, she served as the Deputy General Counsel, after having served nine years as the Associate General Counsel for Contracts, Procurement, and Acquisition Integrity. As a recognized expert in government contracts, she has been a frequent panelist and lecturer on government contracts, and she was awarded NASA's Exceptional Achievement Medal for her litigation accomplishments. Her NASA legal career began at Goddard Space Flight Center, after receiving a Bachelor's from Smith College and a J.D. from Georgetown University Law Center.

EXTENDED BIO - *http://www.nasa.gov/offices/ogc/about/sumara_bio.html*

DEPUTY GENERAL COUNSEL
MR. E. JASON (JAY) STEPTOE

Jay Steptoe was appointed NASA Deputy General Counsel in August 2014. He joined the General Counsel's Office in January 1990 and managed NASA's commercial and international law practices in various capacities since 1999, most recently as Associate General Counsel for International Law since 2005. Before joining NASA, Jay was an attorney in the Office of the Assistant General Counsel for International Law at the U.S. Department of Transportation, specializing in space launch regulation, international aviation, and trade law. Prior to joining the Executive Branch, he was staff counsel to the U.S. Senate Judiciary Committee and its Antitrust and Administrative Practice and Procedure subcommittees.

EXTENDED BIO - *http://www.nasa.gov/offices/ogc/about/steptoe_bio.html*

IMAGE 39.2

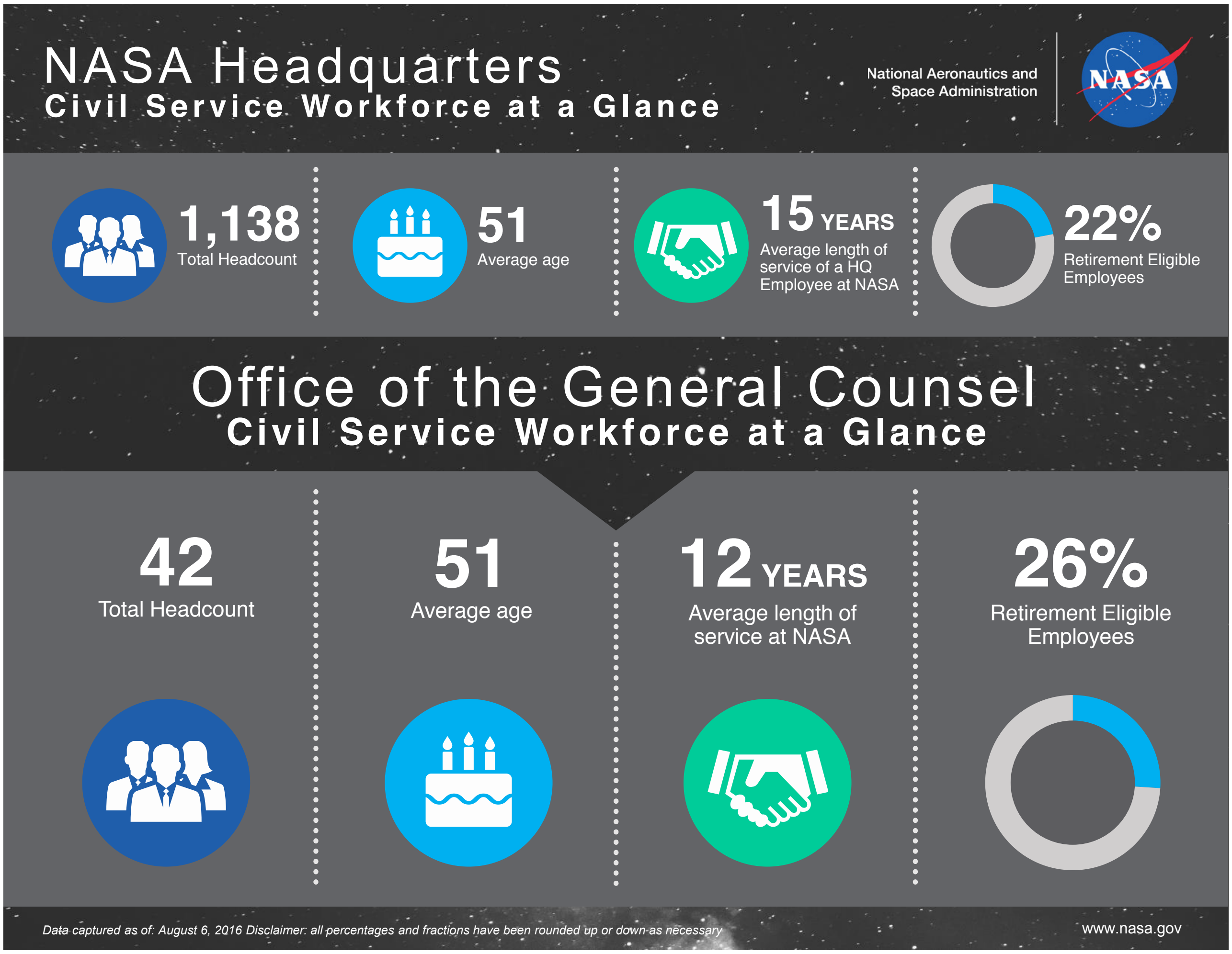


Figure 39.2 Office of the General Counsel Workforce at a Glance

IMAGE 39.3

SPACE COMMERCIALIZATION INITIATIVES

OGC supports NASA's space commercialization initiatives by counseling clients on applicable legal and regulatory structures, interagency efforts to enable innovative commercial activities, legislation that enables use of commercial suppliers, and agreements supporting collaborative efforts to advance the commercial use of space. Examples include Moon Express payload review, Government Astronaut legislation, ISS National Lab, the KSC Pad 39A lease, and NASA's agreement to support the SpaceX Red Dragon mission.

MISSION TO IMPROVE LIFE ON EARTH

OGC supports NASA's mission to improve life on Earth through protecting NASA intellectual property, managing the Agency's highest awards for innovation through the Inventions and Contributions Board and supporting technology transfer. Recent areas of success include increased reporting of new technologies, gift of certain NASA patents to the public domain, increased engagement with early stage companies, and establishment of a publicly accessible, Agency-wide software repository.

KNOWLEDGE MANAGEMENT

In partnership with the Office of the Chief Information Officer, OGC is incorporating best-practices from private industry and developing a knowledge management system utilizing existing Agency IT collaboration platforms (e.g., Sharepoint and ExploreNet) and, eventually, knowledge sharing tools similar to those utilized by global law firms and other multi-office organizations. Consistent with the NASA Operating Model, the effort is designed to establish a more integrated Agency-wide legal team that will maintain required legal capabilities to meet current and future mission needs.

SUPPORT BUSINESS SERVICE ASSESSMENT (BSA)

Through the execution of the BSA, NASA is defining the health of each business service area, identifying opportunities for optimization, and developing risk-informed recommendations to establish a more efficient operating model that maintains a minimum set of capabilities and meets current and future mission needs. OGC serves as a participant, subject-matter expert, and advisor to several ongoing BSA efforts. The Human Capital BSA and the Procurement BSA highlight the unique value NASA attorneys bring to the process.

IMAGE 39.4

HUMAN CAPITAL (HC) BSA

An OGC executive served on the Core Team responsible for defining the BSA's goals and gathering data that led to recommended changes to the way HC serves NASA. The Core Team found many opportunities to enable better HC operations. OGC also ensured that recommended changes comply with federal laws, rules, and regulations. An OGC executive was also selected to lead the team responsible for recommending how to implement changes regarding the recruitment, selection, and training of supervisors. Due to the legal nature of the work of the Office of Human Capital, OGC's input has been critical to achieving the BSA's goal for HC to operate as an enterprise community, leveraging strengths and resources across Centers, consolidating certain activities, and ensuring compliance while still delivering excellent HC products and services to NASA.

PROCUREMENT BSA

Acquisition actions represent a significant portion of NASA's budget (more than 80%). As such, it is critical that NASA's procurement organization deliver optimal business solutions. The recent BSA of NASA's procurement function focused on enhancing the efficiency of how the Office of Procurement together with the procurement offices at each of the Centers support NASA's evolving mission needs. The BSA looked at the health of the procurement service and identified opportunities for optimization. OGC has been and will continue to be involved in implementing the BSA initiatives to ensure legal compliance and to manage legal risk. For instance, to the extent changes are made to NASA's existing acquisition processes, the Agency will incur a higher level of bid protest risk. OGC is helping ensure the Agency is able to anticipate and respond appropriately to such legal risk.

! ADDITIONAL RESOURCES

- www [About OGC]
- www [Ethics Program Website]
- www [Headquarters and Center Chief Counsel Contacts Website]
- www [Acquisition Integrity Program Website]

OFFICE OF INSPECTOR GENERAL (OIG)

MISSION STATEMENT

Inspector General Act of 1978 established Offices of Inspectors General (OIG) at agencies throughout the federal government to promote economy, efficiency, and effectiveness and to detect and prevent crime, fraud, waste, and abuse in federal programs and operations. The NASA Inspector General (IG) is nominated by the President and confirmed by the Senate to conduct independent and objective audits and investigations of NASA programs and report findings and recommendations to the Administrator, Congress, and the public. NASA policy requires Agency employees to cooperate with the OIG (NPD 9800.1B, NASA OIG Programs).

OFFICE WEBSITE *- https://oig.nasa.gov/*

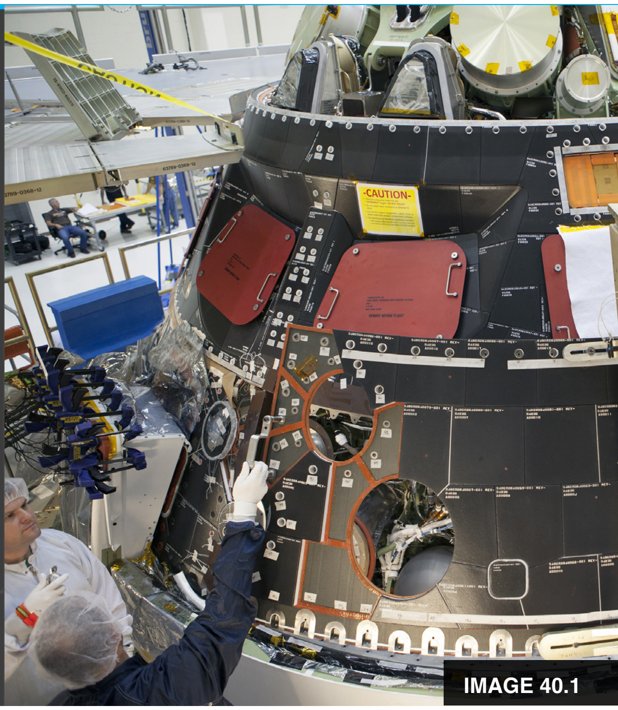


IMAGE 40.1

OFFICE OF INSPECTOR GENERAL CORE FUNCTIONS

OFFICE OF INSPECTOR GENERAL CORE FUNCTIONS INCLUDE:

- Conduct audits and investigations of NASA programs and operations
- Report to the Attorney General violations of Federal law
- Audit the Agency's financial statements
- Annually identify top management and performance challenges facing NASA
- Prepare semi-annual reports summarizing OIG activities

OFFICE OF INSPECTOR GENERAL ORGANIZATION

The OIG's front office is comprised of the IG, Deputy Inspector General, Executive Officer, and Investigative Counsel. In addition, the OIG has two operational units – the Office of Audits and the Office of Investigations – and two support units – the Office of Management and Planning and the Office of Counsel. The OIG's workforce consists of approximately 200 full time civil servants stationed at NASA Headquarters and 12 other locations on or near NASA Centers.

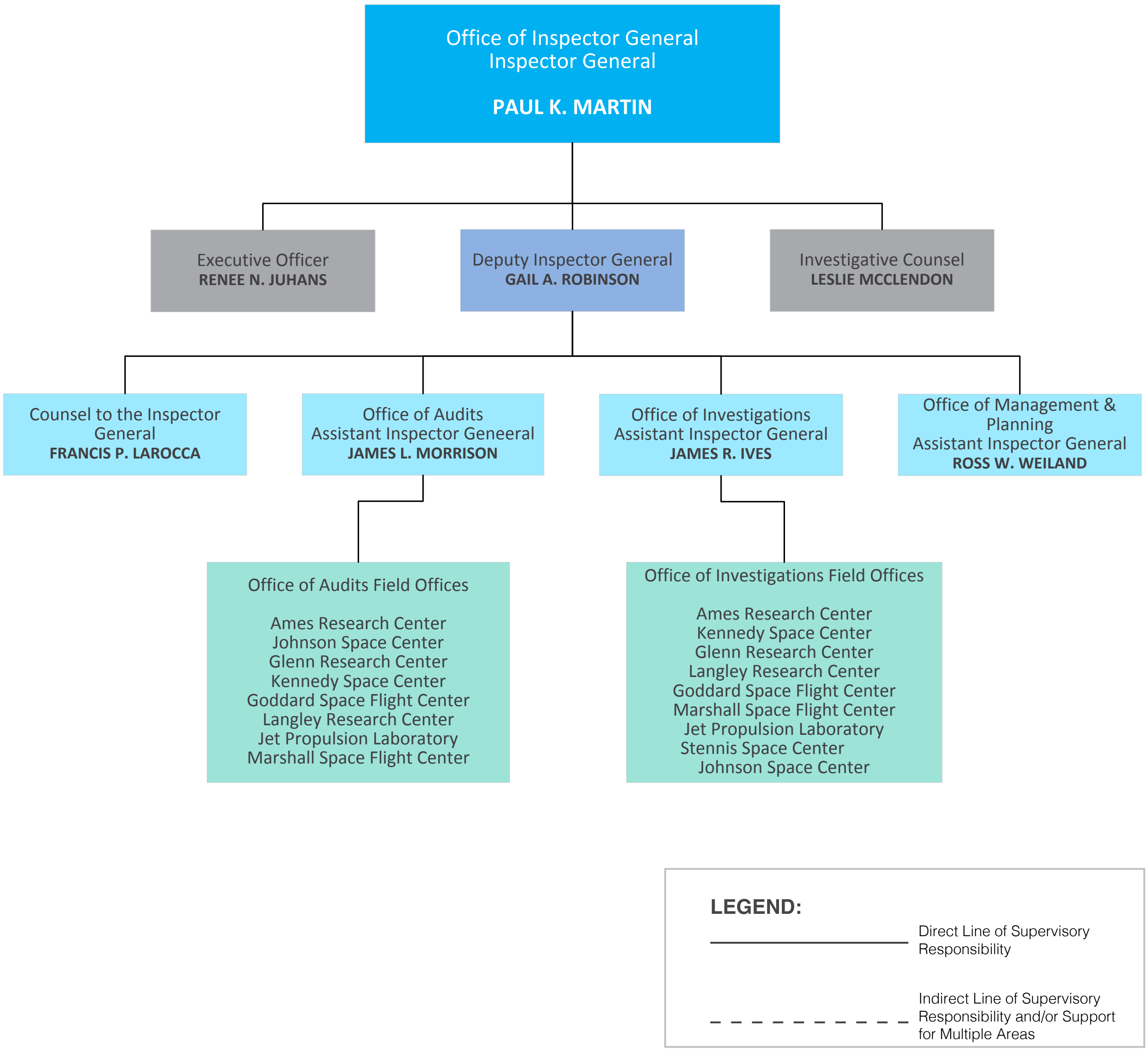


Figure 40.1 Office of Inspector General (OIG) Organization Chart

INSPECTOR GENERAL
MR. PAUL K. MARTIN

Mr. Martin was confirmed by the United States Senate as NASA Inspector General on November 20, 2009. Prior to his NASA appointment, Mr. Martin served as the Deputy Inspector General at the U.S. Department of Justice, Office of The Inspector General (OIG). In that capacity, he assisted Inspector General in managing the audit, inspection and investigative activities of the office's 425 employees. From 2001 to 2003, he served as Counselor to Inspector General, and from 1998 to 2001 he served as Special Counsel to Inspector General.

Before joining the Department of Justice OIG, Mr. Martin spent 13 years at the U.S. Sentencing Commission in a variety of positions, including 6 years as the Commission's Deputy Staff Director.
EXTENDED BIO - *https://oig.nasa.gov/orgCharts/inspector_general.html*

DEPUTY INSPECTOR GENERAL
MS. GAIL A. ROBINSON

Ms. Robinson has served as the Deputy Inspector General since June 2010. As the Deputy Inspector General, Ms. Robinson assists Inspector General in managing the full range of programs and activities in the NASA OIG.

Prior to her appointment as Deputy Inspector General, Ms. Robinson served as General Counsel for the U.S. Department of Justice OIG. In that position, she was responsible for providing advice to Inspector General and OIG senior managers on a wide variety of legal matters. Prior to joining the OIG community, Ms. Robinson worked at a private law firm and as an attorney for a non-profit organization. She also served as a law clerk on the United State Court of Appeals for the District of Columbia.
EXTENDED BIO - *https://oig.nasa.gov/orgCharts/deputy_inspector_general.html*

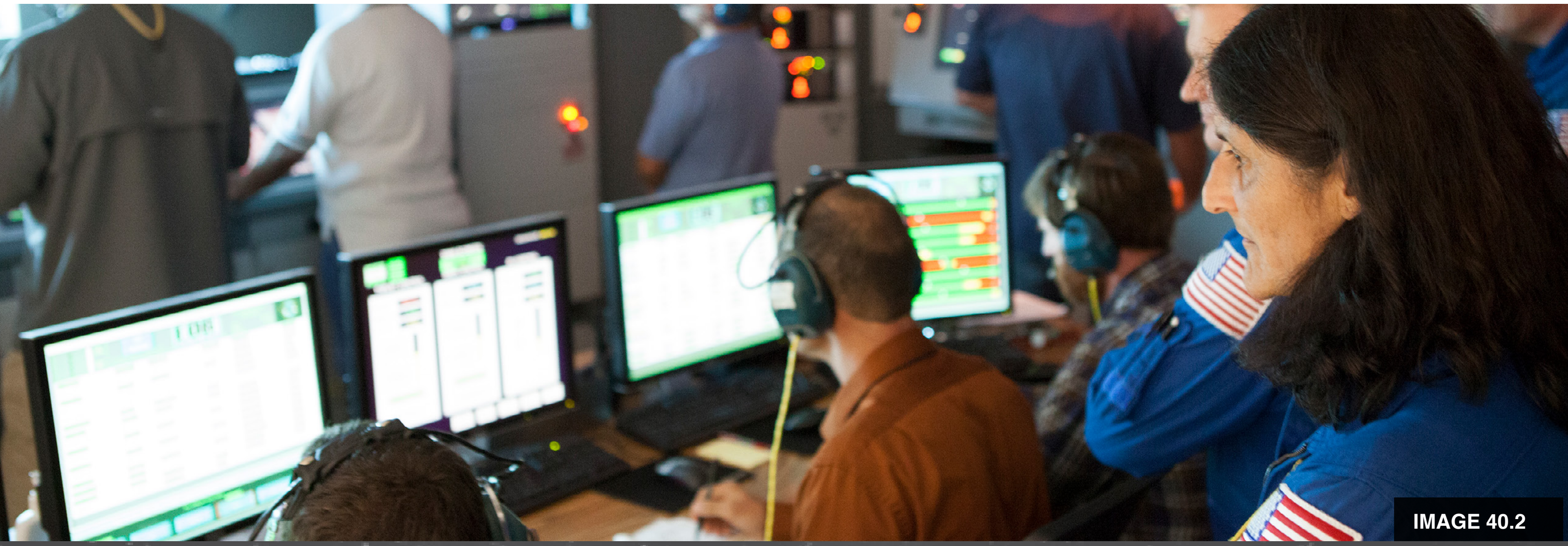


IMAGE 40.2

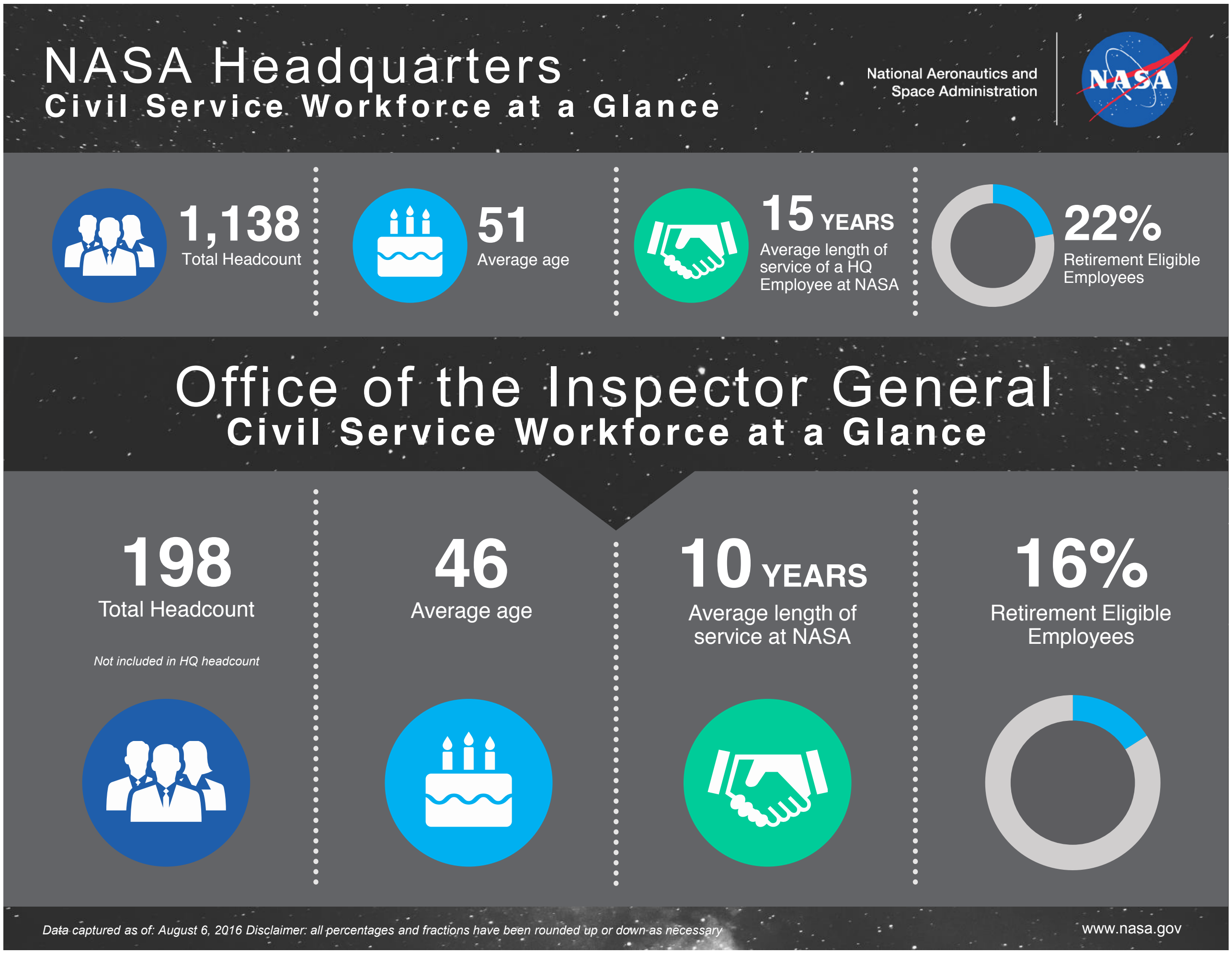


Figure 40.2 Office of Inspector General Workforce at a Glance

IMAGE 40.3

OFFICE OF INSPECTOR GENERAL REPORT

Each year, the OIG issues a report identifying the top management and performance challenges facing NASA. In the November 2015 report, eight challenges were identified:

- Space Flight Operations in Low Earth Orbit: Managing the International Space Station and the Commercial Cargo and Crew Programs
- Positioning NASA for Deep Space Exploration: Developing the Space Launch System, Orion Capsule, and associated Ground Systems, and Mitigating Health and Performance Risks for Extended Human Missions
- Managing NASA's Science Portfolio
- Ensuring the Continued Efficacy of the Space Communications Networks
- Overhauling NASA's Information Technology Governance
- Securing NASA's Information Technology Systems and Data
- Managing NASA's Aging Infrastructure and Facilities
- Ensuring the Integrity of the Agency's Contracting and Grants Processes

FOR THE FULL REPORT, VISIT *- https://oig.nasa.gov/NASA2015ManagementChallenges.pdf*

ADDITIONAL RESOURCES

Issued Audit Reports

Audit Announcements

Semi-Annual Report to Congress

OIG Press Releases

OIG Videos

Congressional Testimony

NASA FIELD CENTER PROFILES

AMES RESEARCH CENTER (ARC)

MISSION STATEMENT

On behalf of the Agency Ames Research Center (ARC) enables exploration through selected developments, innovative technologies, and interdisciplinary scientific discovery. ARC provides leadership in astrobiology, small-satellites; technologies for crew exploration vehicles, crew launch vehicles, human launch vehicles, the search for habitable planets, supercomputing, intelligent/adaptive systems, advanced thermal protection, and airborne astronomy. ARC develops tools for a safer, more efficient national airspace and unique partnerships benefiting NASA's mission.

CENTER WEBSITE -https://www.nasa.gov/centers/ames/home/index.html

RESEARCH PARK - https://www.nasa.gov/researchpark

ARC OVERVIEW VIDEO - http://www.nasa.gov/centers/ames/video

IMAGE 42.1

AMES RESEARCH CENTER CORE FUNCTIONS

ADVANCED COMPUTING AND IT SYSTEMS

Support NASA Mission Directorates with supercomputer high-fidelity modeling, analysis, and simulation capabilities.

AEROSCIENCE

Study airflow and turbulence using wind tunnels and unique labs for fluid mechanics, aeroacoustics, and computational fluid dynamics.

AIR TRAFFIC MANAGEMENT

Provide advanced modeling and simulation to evaluate new tools in airspace design, traffic flow, and optimization.

ASTROBIOLOGY AND FUNDAMENTAL BIOLOGY

Conduct biological research and technology development necessary to enable NASA's long-term human exploration mission.

INTELLIGENT ADAPTIVE HUMAN AND ROBOTIC SYSTEMS

Explore extreme environments and remote locations to advance human-robot systems with increasing autonomy.

SPACE AND EARTH SCIENCE

Lead research in astrobiology, astronomy (especially in the infrared), molecular astrophysics and planetary science, such as Kepler, NASA's first mission to discover exoplanets around other stars. Provide leadership in airborne Earth science campaigns, and provide a platform for collaboration and knowledge sharing on the NASA Earth Exchange.

ENTRY, DESCENT, AND LANDING SYSTEMS

Develop and test every NASA robotic and human-rated spacecraft entering a planetary atmosphere or returning to Earth.

END-TO-END LOW COST SPACE MISSIONS

Lead Center within NASA for small satellites that exemplify small, rapid, low-cost and risk-tolerant approaches.

AMES RESEARCH CENTER DESCRIPTION

Ames Research Center (ARC/Ames) is located at Moffett Field, California, in the heart of California's dynamic Silicon Valley. Ames has always been a center of innovation and creativity. Ames assets include NASA's Astrobiology Institute (NAI), the Solar System Exploration Research Virtual Institute (SSERVI), the NASA Aeronautics Research Institute (NARI), the Mars Climate Modeling Center (MCMC), and the NASA Research Park, a world-class, shared-use research, development, and education campus comprising more than 100 on-site partners working together on innovation and entrepreneurship. ARC serves as host to other federal, military, and civilian organizations, such as the California Air National Guard.

Resident at Ames are many unique national facilities, including the world's largest wind tunnel; one of the nation's most capable supercomputers, Pleiades; the Quantum Artificial Intelligence Laboratory (QuAIL) to explore the potential for quantum computers to solve difficult optimization problems in aeronautics, Earth and space sciences, and space exploration; several state-of-the-art flight simulators; the arc jet complex, which is the only such facility at NASA to simulate the extreme conditions of atmospheric entry; and a Mars wind tunnel.

ARC JET COMPLEX (ARC JET)

The Arc Jet Complex is NASA's only facility capable of simulating the extreme conditions of atmospheric entry, using an electrical discharge (arc) to create plasma flows that simulate the heat and pressures needed to qualify Thermal Protection System (TPS) materials and systems for flight. This rigorous testing supports NASA's exploration initiatives, such as NASA's Orion multipurpose crew vehicle being developed for future Mars and asteroid missions and the safe return of astronauts to Earth.

NASA ADVANCED SUPERCOMPUTING (NAS) HIGH-END COMPUTER CAPABILITY (HECC)

NASA Advanced Supercomputing (NAS) at Ames operates the High-End Computing Capability (HECC) project, providing world-class high-end computing, storage, and associated services to enable scientists and engineers supporting NASA missions to broadly and productively employ large-scale modeling, simulation, and analysis to achieve successful mission outcomes. **NASA Quantum Artificial Intelligence Laboratory (QuAIL)** begins with the D-Wave Two™ quantum computer, evaluating various quantum computing approaches to help address NASA challenges.

VERTICAL MOTION SIMULATOR (VMS)

The Vertical Motion Simulator (VMS) is a unique six-degree-of-freedom flight simulation complex that provides scientists and engineers with exceptional tools to explore, define, and solve issues in both spacecraft design and mission operations. Offering unequaled range of motion -- as much as 60 feet vertically and 40 feet horizontally – the VMS provides high-fidelity sensory cues unsurpassed at simulating aerospace vehicles for the entire flight envelope.

NATIONAL FULL-SCALE AERODYNAMICS COMPLEX (NFAC)

The National Full-Scale Aerodynamics Complex (NFAC) is home to the two largest wind tunnels in the world. The 40-by-80-foot and the 80-by-120-foot wind tunnels provide aerodynamic testing capabilities to the Department of Defense, NASA, other government agencies, and commercial industries.

UNITARY PLAN WIND TUNNEL (UPWT)

The Unitary Plan Wind Tunnel (UPWT) is a research facility used extensively to design and test new generations of aircraft, both commercial and military, as well as NASA space vehicles including the space shuttle. The facility was completed in 1955 and is one of five facilities created after the 1949 Unitary Wind Tunnel Plan Act supporting aeronautics research.

NASA RESEARCH PARK (NRP)

The NASA Research Park (NRP) is a world-class, shared-use research, development, and education campus comprising more than 100 on-site partners working together on innovation and entrepreneurship. Ames serves as host to other federal, military, and civilian organizations, such as the California Air National Guard.

AMES RESEARCH CENTER ORGANIZATION

Ames Research Center is organized by Directorates, there are currently twelve Directorates. Ames has two Associate Directors, one responsible for Research and Technology and one responsible for Mission Support.

The Center organizational chart provides insight into the official roles and relationships within ARC.

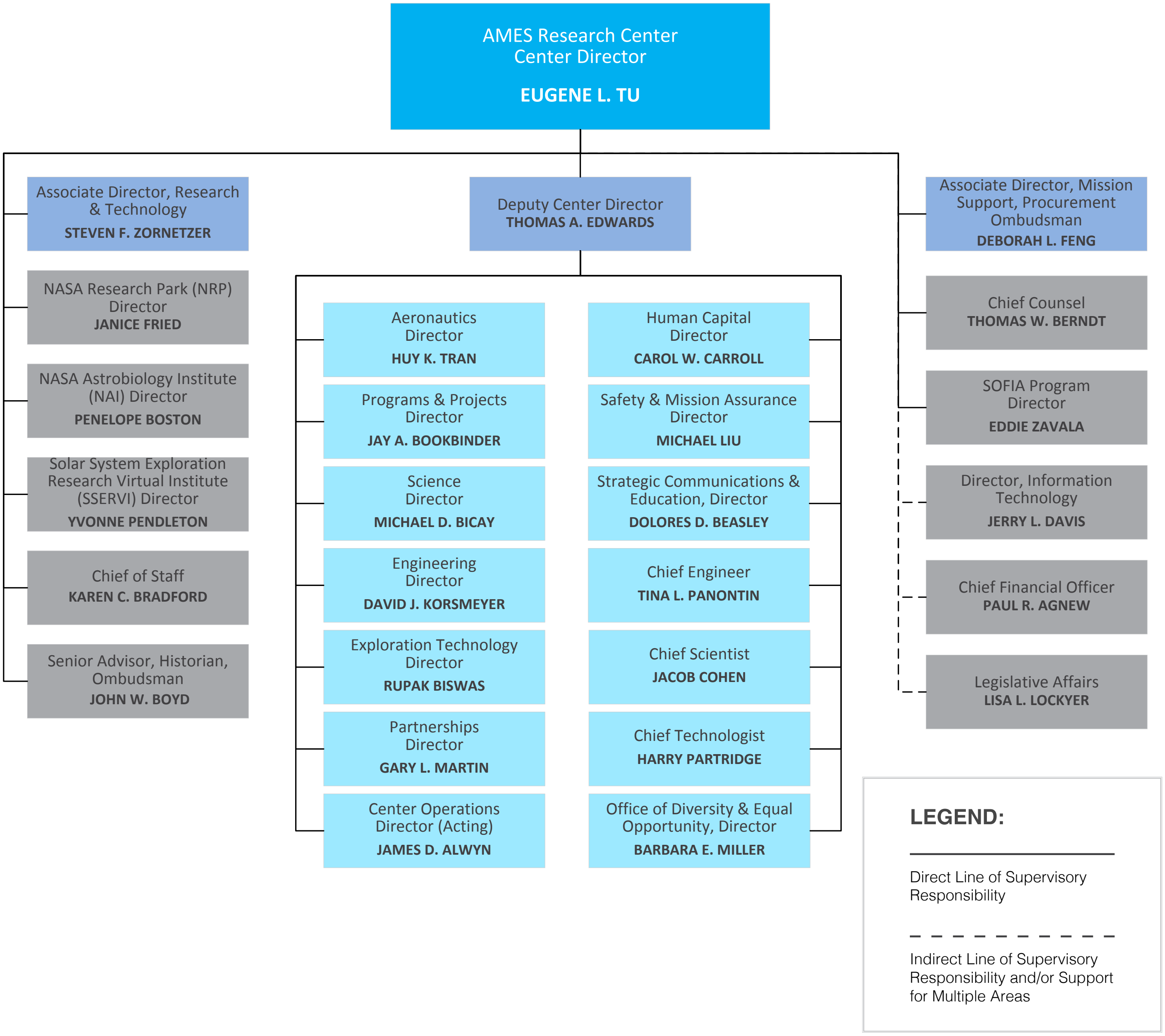


Figure 42.1 Ames Research Center (ARC) Organization Chart

CENTER LEADERSHIP CENTER
DR. EUGENE L. TU

Dr. Eugene L. Tu is the Center Director at NASA's Ames. Tu was most recently Director of Exploration Technology at Ames, a position he held from November 2005 until his selection as Ames Center Director in May 2015. There he led four Technology Research and Development divisions. Tu began his career as a research scientist conducting computational fluid dynamics research. After progressing through various research and managerial positions in such fields as computational aerodynamics, information technology (IT), and high performance computing and communications, he became director of Exploration Technology in 2005. Tu earned his Bachelor's degree in Mechanical Engineering from the University of California, Berkeley, in 1988, and both his Master's degree and Doctorate from Stanford.
EXTENDED BIO - *http://www.nasa.gov/ames/center-director-eugene-tu*

DEPUTY CENTER DIRECTOR
DR. THOMAS A. EDWARDS

Dr. Thomas A. Edwards is the Deputy Center Director at NASA's Ames. Edwards was most recently Director of Aeronautics at Ames, with responsibility for research in aviation operations, flight vehicle technology and design, and fundamental aerodynamics. In this position, he also was also responsible for the operation of national flight simulation and wind tunnel facilities. He began his career with NASA in 1983, and has served in a variety of research and managerial assignments in fields including Computational Fluid Dynamics, Aircraft Design, Aerothermodynamics, Information Technology, and Aviation Operations. Edwards is a graduate of Princeton University, with Master's and Doctorate degrees in Aeronautics and Astronautics from from Stanford University.
EXTENDED BIO - *http://www.nasa.gov/ames/deputy-center-director-thomas-edwards*

ASSOCIATE DIRECTOR FOR RESEARCH AND TECHNOLOGY
DR. STEVEN F. ZORNETZER

Steven F. Zornetzer was formerly a neurobiologist and professor of neuroscience interested in the problem of how the brain processes information. Zornetzer has evolved from academic to a creative and dynamic leader and senior executive at NASA's Ames Research Center in Silicon Valley. Currently serving as Ames' Associate Director, he formerly served as Director of Research and prior to that as Director of Information Sciences and Technology at Ames. Before joining NASA in 1997, he headed the Life Sciences Directorate for the Office of Naval Research (ONR). In 2008 he received the Presidential Distinguished Executive Award and in 2010 NASA's Outstanding Leadership Medal. He is a driver for NASA Ames' leadership in environmental sustainability.
EXTENDED BIO - *http://www.nasa.gov/centers/ames/about/people/zornetzer.html*

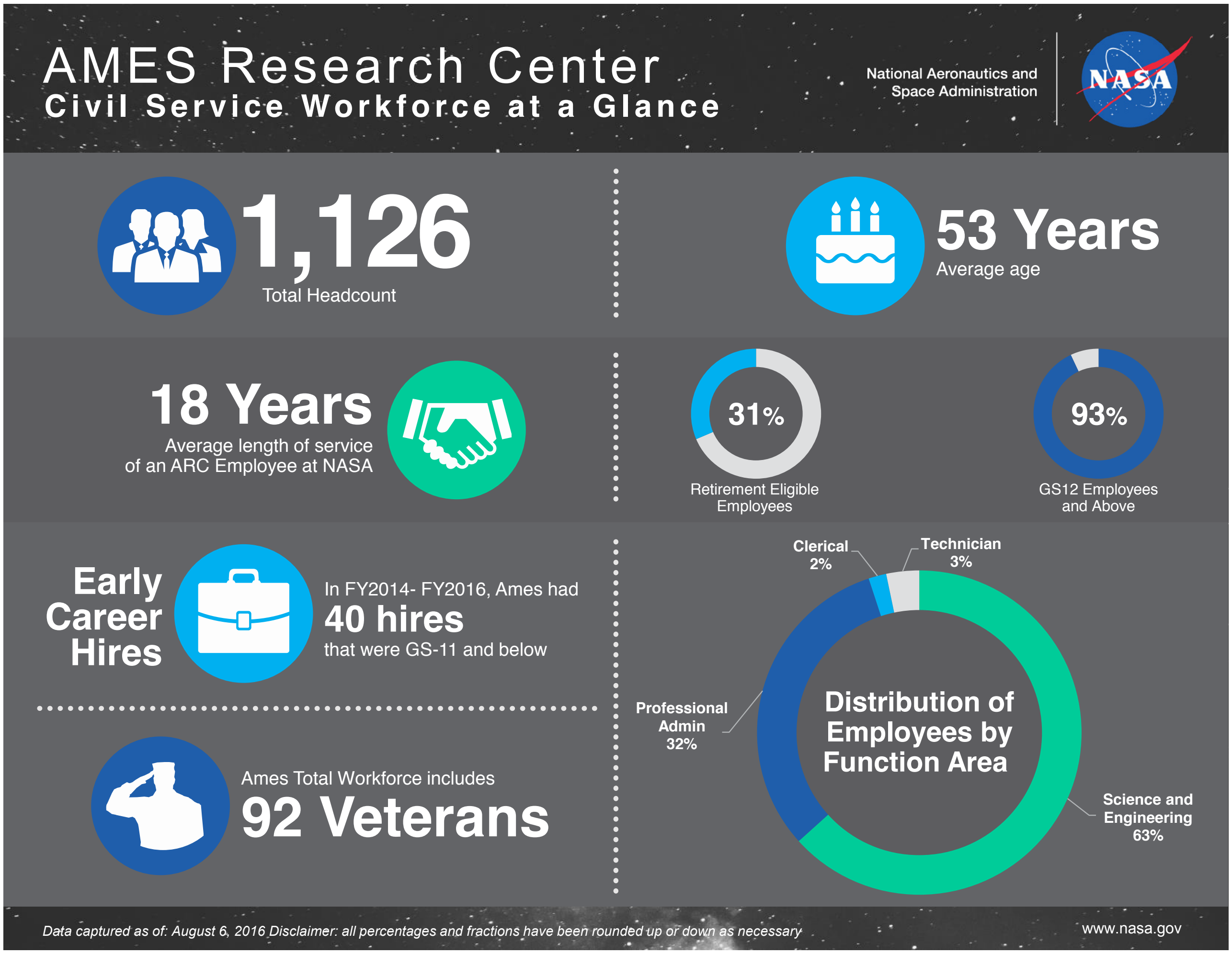


Figure 42.2 Ames Research Center Workforce at a Glance

ADDITIONAL RESOURCES

- [ARC Astrogram]
- [ARC Podcast]
- [ARC Summer Series 2016]

ARMSTRONG FLIGHT RESEARCH CENTER (AFRC)

MISSION STATEMENT

On behalf of the Agency AFRC advances technology and science through flight. AFRC performs flight research and technology integration to revolutionize aviation and pioneer aerospace technology; validates space exploration concepts; conducts airborne remote sensing and science missions; enables airborne astrophysics observation missions to discover the origin, structure, evolution, and destiny of the universe; and supports operations of the International Space Station (ISS) for NASA and the nation. AFRC supports activities across the four NASA Mission Directorates.

CENTER WEBSITE -https://www.nasa.gov/centers/armstrong/home/index.html
YEAR IN REVIEW VIDEO - https://www.youtube.com/watch?v=ixstbyHhsQ0

IMAGE 43.1

ARMSTRONG FLIGHT RESEARCH CENTER CORE FUNCTIONS

RESEARCH ENGINEERING
The capability to design and integrate complex flight experiments to advance the Aeronautics Research Mission Directorate (ARMD) strategic plan.

ATMOSPHERIC FLIGHT RESEARCH
Experimental test pilots and specialized aircraft coupled with processes for airworthiness certification, ground, flight, and range safety to execute the Agency flight missions.

DRYDEN AERONAUTICAL TEST RANGE (DATR)
Ability to safely monitor and control flight activity, and conduct real-time acquisition of telemetry, video tracking, and communications for flight test execution.

TEST FACILITIES
Simulation laboratories and Flight Loads Lab provide the facilities to conduct ground tests in support of flight research operations.

EARTH SCIENCE OPERATION
An appropriately-sized collection of aircraft and ground facilities capable of supporting worldwide science operations.

SUPPORT AIRCRAFT AND MAINTENANCE ORGANIZATION
Versatile aircraft, life support, and backshop capabilities required to conduct the Agency's flight operations effectively.

ARMSTRONG FLIGHT RESEARCH CENTER DESCRIPTION

The Armstrong Flight Research Center (AFRC/Armstrong) is NASA's primary center for atmospheric flight research and operations. The main campus is situated on approximately 830 acres within the confines of Edwards Air Force Base's 308,000-acre property; this includes the 95 buildings that support the flight research missions. The Center also has direct access to the base's taxiways and runways, including its 15,000-foot main runway and approximately 60 miles of dry lakebed runways. In addition, AFRC's location gives it direct access to 20,000 square miles of restricted airspace. This combination of unique attributes permits AFRC to conduct a full range of aeronautical flight research while maximizing the safe operation and recovery of one-of-a-kind flight vehicles.

NASA AFRC executed a 20-year lease in 2007 for 16.4 acres at the Palmdale, CA facility, located about 35 miles southwest of AFRC, and has direct access to the U.S. Air Force Production Flight Test Installation (Plant 42) and its two 12,000-foot runways. This facility has over 420,000 square feet of hangar space, offices, labs, conference accommodations, and storage.

The facility is ideal for collaboration among private industry, visiting scientists and researchers, and aviation-related activity in support of the Stratospheric Observatory for Infrared Astronomy (SOFIA) 747SP airborne telescope and the Earth Science mission aircraft (ER-2, C-20, and DC-8). AFRC manages and operates this leased facility for NASA.

ARMSTRONG FLIGHT RESEARCH CENTER NOTABLE AND UNIQUE FACILITIES

THE MAIN CAMPUS HEADQUARTERS BUILDING

The main campus Headquarters Building, (a 178,584 square foot multi-purpose facility) supports the Dryden Aeronautical Test Range (DATR), various research and test laboratories, engineering office space, and various administrative activities.

THE FLIGHT LOADS LABORATORY (FLL)

The Flight Loads Laboratory (FLL) conducts mechanical-load and thermal studies of structural components and complete flight vehicles in addition to performing calibration tests of vehicle instrumentation for real-time determination of flight loads.

THE RESEARCH AIRCRAFT INTEGRATION FACILITY (RAIF)

The Research Aircraft Integration Facility (RAIF) integrates simulation, vehicle software, and hardware systems under one roof. The RAIF offers high fidelity 6-DOF (six Degrees of Freedom) batch and in-real-time flight simulation capabilities, supporting system integration, and closed-loop verification and validation testing of vehicle components and flight vehicles.

THE CONSOLIDATED INFORMATION TECHNOLOGY CENTER (CITC)

Armstrong's Consolidated Information Technology Center (a 40,000 square foot facility) provides a secure environment and facilitates reliable, secure, and rapid analysis of critical flight research data to prepare AFRC for future research mission data requirements. In addition, the costs of this building over its lifecycle will be much lower. The facility is a LEED silver building.

THE DRYDEN AERONAUTICAL TEST RANGE (DATR)

The Dryden Aeronautical Test Range (DATR) supplies a comprehensive set of resources to control and monitor flight activities, real-time acquisition and reduction of research data, and effective communication of information to flight and ground crews via RADAR (Radio Detection And Ranging), telemetry tracking, communication, and video systems. It also supports the International Space Station (ISS).

ARMSTRONG FLIGHT RESEARCH CENTER ORGANIZATION

For over 70 years, AFRC has been the setting for the exciting and often hazardous job of testing the world's most exotic aircraft. The essential role of flight research continues as part of Armstrong's strategic intent – to remain recognized as the premier flight research and test organization for the validation of high-risk, pioneering aerospace technology, space exploration concepts, and the conduct of science mission observations.

AFRC's project teams have successfully accomplished many of the nation's most complex flight research projects. The Center has created and refined innovative flight research techniques that encompass all phases of flight projects, from complex design through development, fabrication, and operations processes. Through this ongoing refinement, Armstrong continues to expand its world-class capabilities, which include an expert work force, natural infrastructure, unique facilities and aircraft, flexible project management, and a proven operating system.

The Center organizational chart provides insight into the official roles and relationships within AFRC.

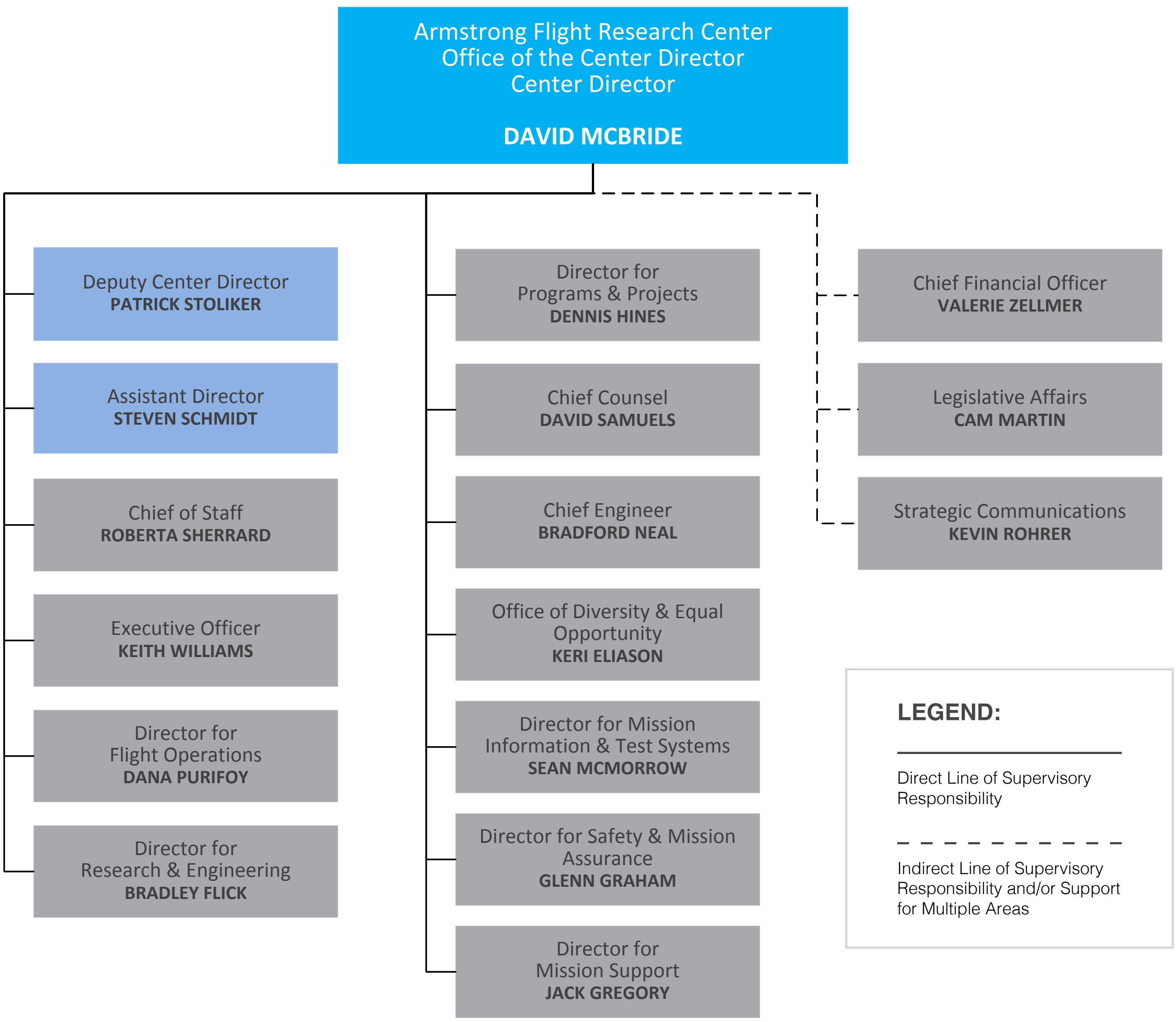


Figure 43.1 Armstrong Flight Research Center (AFRC) Organization Chart

CENTER DIRECTOR
MR. DAVID D. McBRIDE

David D. McBride was appointed Director on January 4, 2010, having served as Acting Director since April 2009. He oversees all aspects of management, strategy, and operations at NASA Armstrong. During his tenure, the Center achieved full operational capability with the highly modified B-747 Stratospheric Observatory for Infrared Astronomy, completed flight evaluation of the X-48B/C hybrid wing body experimental aircraft, transitioned NASA's Global Hawk unmanned aircraft to Science Operations, and demonstrated the NASA Orion spacecraft's launch abort system.

His prior management assignments at NASA Armstrong include serving as Deputy Center Director and Associate Director for programs, where he oversaw the complete portfolio of Center projects supporting exploration, science, and aeronautics.
EXTENDED BIO - *http://www.nasa.gov/centers/armstrong/about/biographies/management/mcbride.html*

DEPUTY CENTER DIRECTOR
MR. PATRICK C. STOLIKER

Patrick C. Stoliker is Deputy Director of NASA's Armstrong Flight Research Center. He assists the Center Director in the management of AFRC, focusing on strategy, business processes, and institutional management.

Mr. Stoliker has held several increasingly responsible management roles at NASA Armstrong, including deputy Associate Director for Operations, five years as Director for Research and Engineering, and Assistant Director for Programs and Projects.

He was also the associate director of Research Engineering, project manager of the Center's implementation team for the Integrated Financial Management System, and six years as chief of the Controls and Dynamics Branch.
EXTENDED BIO - *http://www.nasa.gov/centers/armstrong/about/biographies/management/stoliker.html*

ASSISTANT DIRECTOR
MR. STEVEN G. SCHMIDT

Steven G. Schmidt is the Assistant Director for Strategic Implementation at NASA's Armstrong Flight Research Center. He analyzes and recommends action to integrate or transform strategy, policy, and planning within the Center. He also directs the Public Affairs and Education offices.

Previously he was the Director of the Armstrong Aircraft Operations Facility in Palmdale, California, from 2008 through 2011. Prior to this, he was Deputy Center Director at NASA Armstrong from August 2004 to 2008. From January 2002 through August 2004, Schmidt was a special assistant to the NASA Administrator in Washington, D.C., and Executive Director for the President's Commission on Implementation of U.S. Space Exploration Policy. He was the Executive Secretary on the Columbia Accident Investigation Board.
EXTENDED BIO - *http://www.nasa.gov/centers/armstrong/about/biographies/management/schmidt.html*

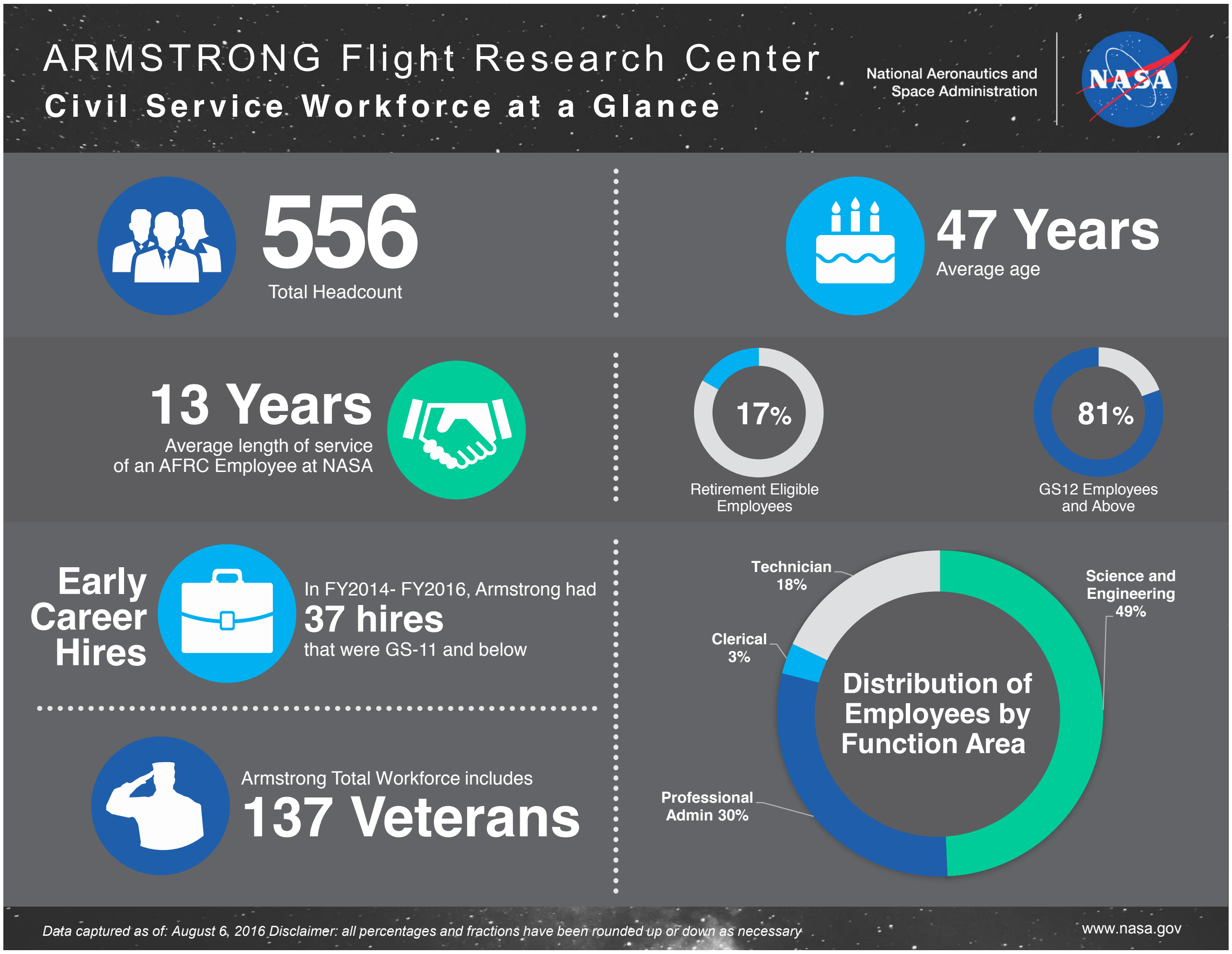


Figure 43.2 Armstrong Flight Research Center Workforce at a Glance

ADDITIONAL RESOURCES

- AFRC Programs and Projects
- AFRC Research and Testbed Aircraft
- AFRC Technologies
- AFRC Capabilities and Facilities

GLENN RESEARCH CENTER (GRC)

MISSION STATEMENT

On behalf of the Agency Glenn Research Center (GRC) drives research, technology, and systems to advance aviation, enable exploration of the universe, and improve life on Earth. The GRC at Lewis Field develops critical space flight systems and technologies to advance the exploration of our solar system and beyond while maintaining leadership in aeronautics. In partnership with U.S. industries, universities, and other government institutions, research and development efforts focus on advancements in air-breathing propulsion, in-space propulsion and cryogenic fluids management, communications technology and architecture design/developments, aerospace, power systems, architectures, and technologies including energy storage and power conversion, advanced materials specializing in materials for extreme environments, and physical sciences including biomedical technologies in space.

CENTER WEBSITE - http://overview.grc.nasa.gov

IMAGE 44.1

GLENN RESEARCH CENTER CORE FUNCTIONS

AIR-BREATHING PROPULSION
Develop and test new technologies and systems aimed at significantly advancing air-breathing propulsion for aerospace vehicles that enable reduced energy consumption, noise and emissions, improved safety operations, faster modes of air transportation, and reduced costs for aerospace travel.

COMMUNICATIONS TECHNOLOGY AND DEVELOPMENT
Develop future communications architectures and provide advanced communications technologies to enable order-of-magnitude increases in mission data transfer and continuous, cost-effective, and secure high-data-rate communications for aeronautics and space customers.

IN-SPACE PROPULSION AND CRYOGENIC FLUIDS MANAGEMENT
Develop and test enhancements for spacecraft propulsion systems, propulsion stages, and cryogenic fluid flight systems to enable new mission capability.

POWER, ENERGY STORAGE, AND CONVERSION
Develop new technologies and systems for power generation, energy conversion and storage, and power management and distribution from concept to flight for aeronautics and space customers.

MATERIALS AND STRUCTURES FOR EXTREME ENVIRONMENTS

Manage the lifecycle of advanced materials, structures, and mechanisms to enable high-performance, long-life aerospace systems subjected to the extreme environments encountered in aircraft engines, space propulsion systems, planetary reentry and surface operations, advanced power systems, and long-duration space travel.

PHYSICAL SCIENCES AND BIOMEDICAL TECHNOLOGIES IN SPACE

Support research in advanced physical and biomedical systems and technologies which will enable sustainable space exploration.

GLENN RESEARCH CENTER DESCRIPTION

Located at Lewis Field (350 acres next to Cleveland Hopkins International Airport) and Plum Brook Station (6,500 acres in Sandusky, Ohio), the Glenn Research Center (GRC) contains a unique collection of world-class laboratories and test facilities. The Lewis Field site and Plum Brook Station host many facilities designed to test aviation and spaceflight hardware.

The GRC facilities are uniquely positioned to meet the technological needs of NASA and its partners, now and into the future. GRC sites at Lewis Field in Cleveland, Ohio and Plum Brook Station in Sandusky, Ohio, are home to 25 major test facilities, four different highly capable research aircraft and over 100 research/engineering laboratories.

The Space Power Facility at GRC's Plum Brook Station houses the world's largest and most powerful space environment simulation facilities including: the Space Simulation Vacuum Chamber—measuring 100 feet in diameter by 122 feet high; the Reverberant Acoustic Test Facility—the world's most powerful spacecraft acoustic test chamber (capable of simulating the noise of a spacecraft launch up to 166 decibels or as loud as the thrust of 20 jet engines); and the Mechanical Vibration Facility—the world's highest capacity and most powerful spacecraft shaker system that subjects test articles to the rigorous conditions of launch.

In addition to the Space Power Facility, GRC has a full suite of space simulation environments including a large vacuum chamber with the world's fastest pumping capability, the world's only facility capable of testing full-scale, upper-stage launch vehicles and rocket engines under simulated high-altitude conditions, and a unique and world-class ground-based test rig that can accurately simulate atmospheric conditions for any planet or moon in the solar system.

GRC is home to several aero science ground test facilities including the 8 x 6 foot Transonic Wind Tunnel, the 9 x 15 foot Low Speed Wind Tunnel, the 10 x 10 foot Supersonic Wind Tunnel, the Propulsion Systems Laboratory, and the Icing Research Tunnel. These facilities deliver significant design and verification contributions for industry, academia, military, and NASA for fully operational propulsion systems testing at sea level and at altitude, acoustics measurements, and airframes, and the development, testing, and certification of methods for engine and aircraft icing.

FOR INFORMATION ON THESE UNIQUE FACILITIES VISIT - *https://facilities.grc.nasa.gov/*

IMAGE 44.2

GLENN RESEARCH CENTER ORGANIZATION

GRC is organized as a matrix organization with customer-facing project offices that coordinate with the HQ Mission Directorates. The project offices, in turn work with implementing organizations at the Center. This construct enables rapid redeployment of skilled personnel and resources based on fluctuating Agency Mission priorities.

The Plum Brook Station is an integral part of GRC, located 50 miles west of Lewis Field. The institutional capabilities including IT infrastructure, institutional facilities management, procurement, and chief financial officer functions are covered by the management team at GRC, and the Director of Plum Brook Station reports to the GRC Center Director.

The NASA Safety Center is an Agency function that resides outside the Center gates but in close proximity to GRC. The institutional capabilities are covered by the management team at GRC, but the NASA Safety Center Director reports to the HQ Office of Safety and Mission Assurance.

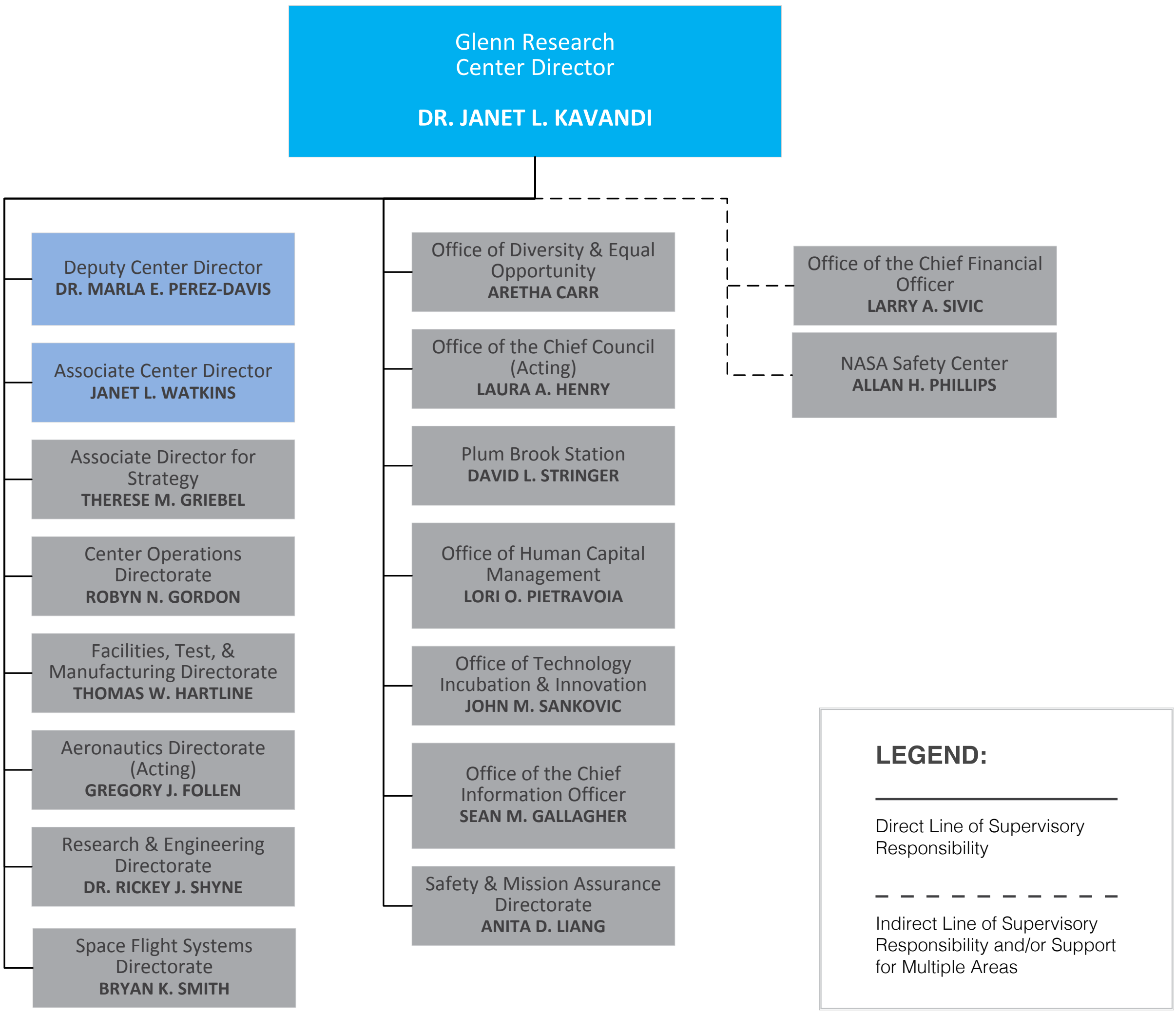


Figure 44.1 Glenn Research Center (GRC) Organization Chart

CENTER DIRECTOR
DR. JANET L. KAVANDI

Dr. Janet L. Kavandi currently serves as Director of NASA GRC. She previously served at Johnson Space Center in Houston, Texas, as the Director of Flight Crew Operations and the Deputy Director of the Health and Human Performance Directorate. She was selected as a NASA astronaut in December 1994, and is a veteran of three space flights, serving as a Mission Specialist on STS-91 in 1998, STS-99 in 2000, and STS-104 in 2001. Dr. Kavandi was born in Springfield, Missouri, and holds Bachelor and Master of Science degrees in Chemistry and a Doctorate in Analytical Chemistry. Dr. Kavandi has been recognized with a Presidential Rank Award, two NASA Outstanding Leadership Medals, two Exceptional Service Medals, and three NASA Space Flight Medals.
EXTENDED BIO - *https://www.nasa.gov/content/biography-janet-l-kavandi-dr*

DEPUTY CENTER DIRECTOR
DR. MARLA E. PÉREZ-DAVIS

Dr. Marla E. Pérez-Davis currently serves as Deputy Director of NASA GRC. She previously served as Deputy Director of the Research and Engineering Directorate, Director of the Aeronautics Research Office, Chief of the Project Liaison and Integration Office, and Chief of the Electrochemistry Branch at GRC. Dr. Pérez-Davis, born in Puerto Rico, earned her Bachelor's, Master's and PhD in Chemical Engineering. Dr. Pérez-Davis is the recipient of NASA Outstanding Leadership Medal; 2015 Crain's Women of Note, the Top 25 Elite Business Women, Hispanic Business Magazine; Women of Color Career Achievement; Distinguished Alumni Award Alumni Association of University of Puerto Rico Mayaguez; and the Women in Aerospace Award for Aerospace Awareness.
EXTENDED BIO - *https://www.nasa.gov/centers/glenn/about/bios/perez-davis_bio.html*

ASSOCIATE DIRECTOR
MS. JANET L. WATKINS

Janet L. Watkins serves as the Associate Director at NASA GRC. She previously served as the Technical Expert/In-sourcing and Acting Deputy Director, Manpower, Personnel and Services at Wright Patterson Air Force Base, in Dayton, Ohio, and the Organization Division Chief of Manpower, Personnel and Resources Directorate, United States Air Force (USAF) Headquarters at the Pentagon in Washington, DC. Watkins, born in Ohio, earned her Bachelor's degree in Business Administration and management and her master's degree in public administration. Watkins is the recipient of the Meritorious Civilian Service Award in 2009, Notable Achievement Awards in 2008 and 2001, and the USAF Manpower and Organization Headquarters-level Senior Civilian Award for Professional Excellence.
EXTENDED BIO - *https://www.nasa.gov/centers/glenn/about/bios/watkins_bio.html*

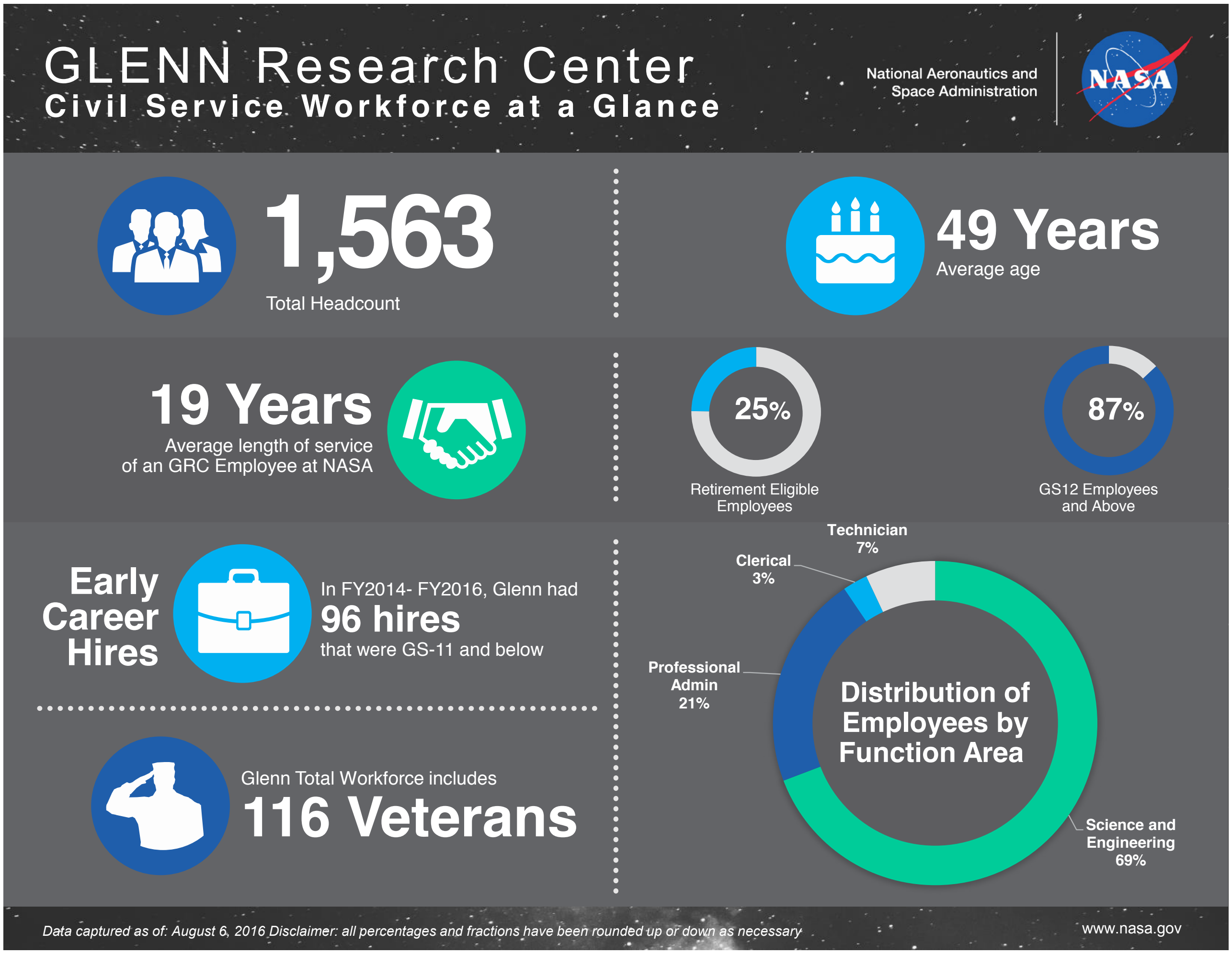


Figure 44.2 Glenn Research Center Workforce at a Glance

ADDITIONAL RESOURCES

- WWW GRC Space Programs
- WWW GRC Research and Engineering
- WWW GRC Aero Programs
- WWW GRC Technologies
- WWW GRC Overview

GODDARD SPACE FLIGHT CENTER (GSFC)

MISSION STATEMENT

On behalf of the Agency Goddard Space Flight Center advances 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. GSFC is 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.

CENTER WEBSITE - https://www.nasa.gov/goddard


IMAGE 45.1

GODDARD SPACE FLIGHT CENTER CORE FUNCTIONS

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

HELIOPHYSICS
Researches the sun and its extended solar system environment (the heliosphere), and interactions of Earth, other planets, small bodies, interstellar gas with the heliosphere, and space weather research.

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

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 AND NAVIGATION
Systems, technologies, and services in support of science, exploration, and space operations missions that are near Earth and up to two million kilometers in deep space.

SUBORBITAL PLATFORMS AND RANGE SERVICES
Programs and services for sounding rockets, balloons, aircraft, and commercial space including NASA's, and the United States' only civil launch facility, Wallops Launch Range.

GODDARD SPACE FLIGHT CENTER CORE FUNCTIONS

SENSOR SYSTEMS AND INSTRUMENT PLATFORMS

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

LARGE-SCALE SCIENTIFIC INFORMATION SYSTEMS, DATA PROCESSING, AND DISSEMINATION

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

IN-SPACE SATELLITE ASSEMBLY AND SERVICING

To enable extended mission operations, reconfiguration, and recovery of existing on-orbit assets, Goddard's services include on-orbit spacecraft refueling and repair, assembly of large structures in orbit using modular designs.

PROGRAM AND PROJECT MANAGEMENT

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

END-TO-END MISSION SYSTEMS ARCHITECTURE AND ENGINEERING

Goddard is one of only three organizations in the U.S. capable of addressing the full lifecycle of science missions, spacecraft, *in situ* and remote sensing instruments, and payloads from identification of the need for data to conduct beneficial research and advanced concepts through implementation, launch operations, data analysis, archive, and distribution.

SAFETY AND 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.

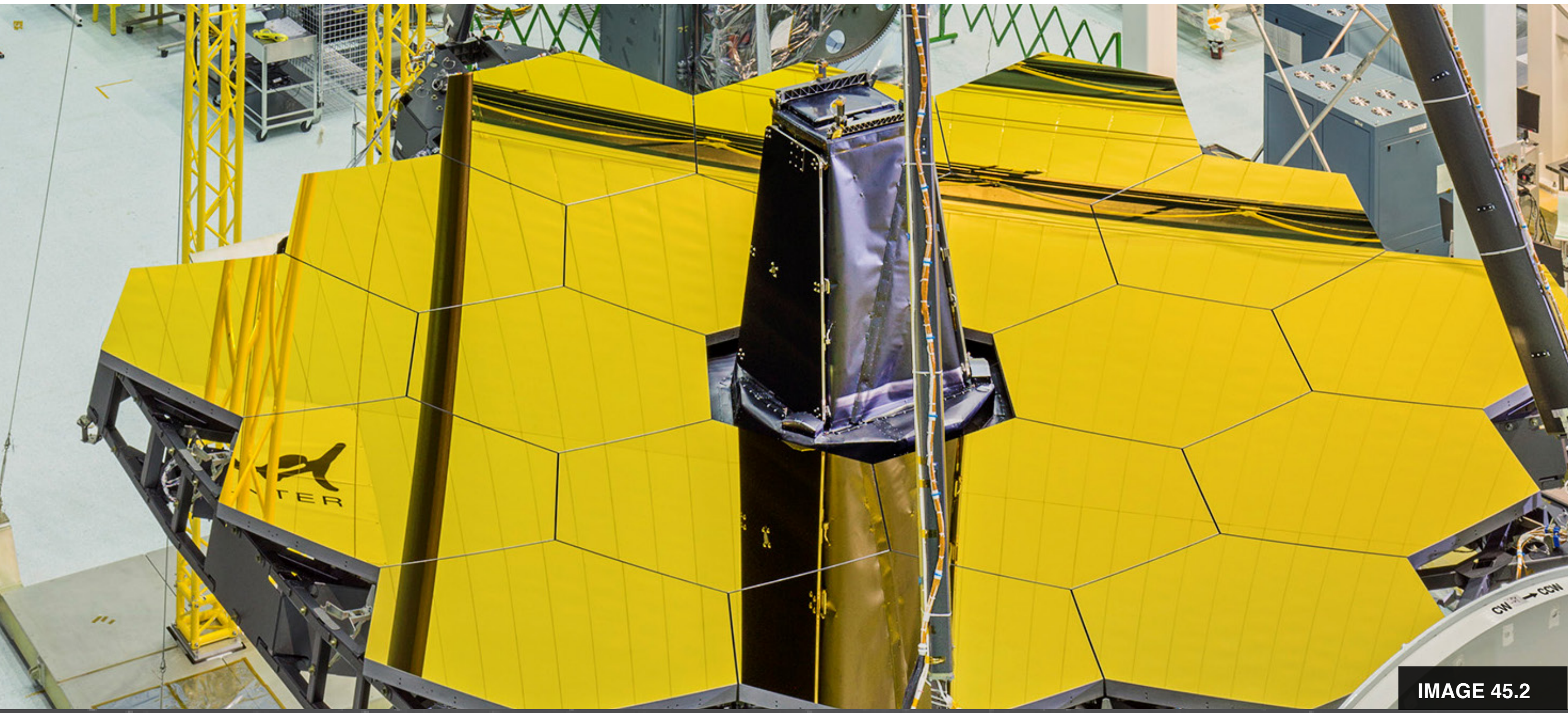


IMAGE 45.2

GODDARD SPACE FLIGHT CENTER DESCRIPTION

NASA's Goddard Space Flight Center (GSFC/Goddard), located in Greenbelt, Maryland, (Including Wallops Flight Facility, Independent Verification and Validation Facility, Goddard Institute for Space Studies, and White Sands) is home to the nation's largest organization of scientists, engineers, and technologists who build spacecraft, instruments, and new technology to study Earth, the sun, our solar system, and the universe.

Located near Washington, DC, Goddard is home to Hubble operations and the upcoming James Webb Space Telescope. Goddard manages communications between Mission Control and orbiting astronauts aboard the International Space Station. Goddard scientists stare into the sun, grind up meteorites for signs of life's building blocks, look into the farthest reaches of space, and untangle the mysteries of our own changing world. Goddard engineers construct sensitive instruments, build telescopes that peer into the cosmos, and operate the test chambers that ensure those satellites' survival.

GODDARD SPACE FLIGHT CENTER COMPONENT FACILITIES

THE GODDARD INSTITUTE FOR SPACE STUDIES (GISS)

The Goddard Institute for Space Studies (GISS), located in New York City, is a component laboratory of Goddard Space Flight Center's Earth Sciences Division. GISS occupies five of seven floors in Columbia University's Armstrong Hall in Manhattan's Morningside Heights neighborhood. GISS specializes in space-based observations, provides a critical perspective for monitoring global climate and developing an understanding of Earth systems.

THE WALLOPS FLIGHT FACILITY (WFF/WALLOPS)

The Wallops Flight Facility (WFF/Wallops) located on Virginia's Eastern Shore, encompasses 6,188 acres of land and has 84 major buildings, including aircraft hangars. Wallops is NASA's principal facility for management and implementation of suborbital research programs, and serves as a test site for new launch technologies. Wallops launches low-cost, versatile suborbital and orbital rockets, balloons, and aircraft in support of Goddard Earth and space science research, and has launched 14,000 rockets from its facilities.

THE INDEPENDENT VERIFICATION AND VALIDATION (IV&V) FACILITY

The Independent Verification and Validation (IV&V) Facility is located in Fairmont, West Virginia. This facility hosts and manages the Agency-level IV&V function which applies system and software engineering best practices to evaluate the correctness and quality of critical and complex software systems throughout the System Development Life Cycle. The NASA IV&V Program was founded under the NASA Office of Safety and Mission Assurance (OSMA) as a direct result of recommendations made by the National Research Council (NRC) and the Report of the Presidential Commission on the Space Shuttle Challenger Accident.

THE WHITE SANDS COMPLEX

The White Sands Complex is located close to the foot of the San Andres Mountains outside Las Cruces, New Mexico. The White Sands Complex hosts antenna dishes that are part of NASA's ground-based communication systems to orbiting spacecraft. The first missions to use these antennas were early space shuttle flights, STS-8 being the first. Later, the Hubble Space Telescope and the International Space Station relied, and continue to rely, on dishes at the White Sands Complex.

GODDARD SPACE FLIGHT CENTER ORGANIZATION

The leadership structure provides the overall management and coordination of the broad and diverse activities and work carried out within and across the organizational elements of the Goddard Space Flight Center. The leadership is accountable for providing overall direction to Goddard's science, engineering, technology, institutional, and administrative organizations and programs in order to successfully accomplish the mission to transform human understanding of Earth and space through innovation, exploration, and discovery.

The Center organizational chart provides insight into the official roles and relationships within GSFC.

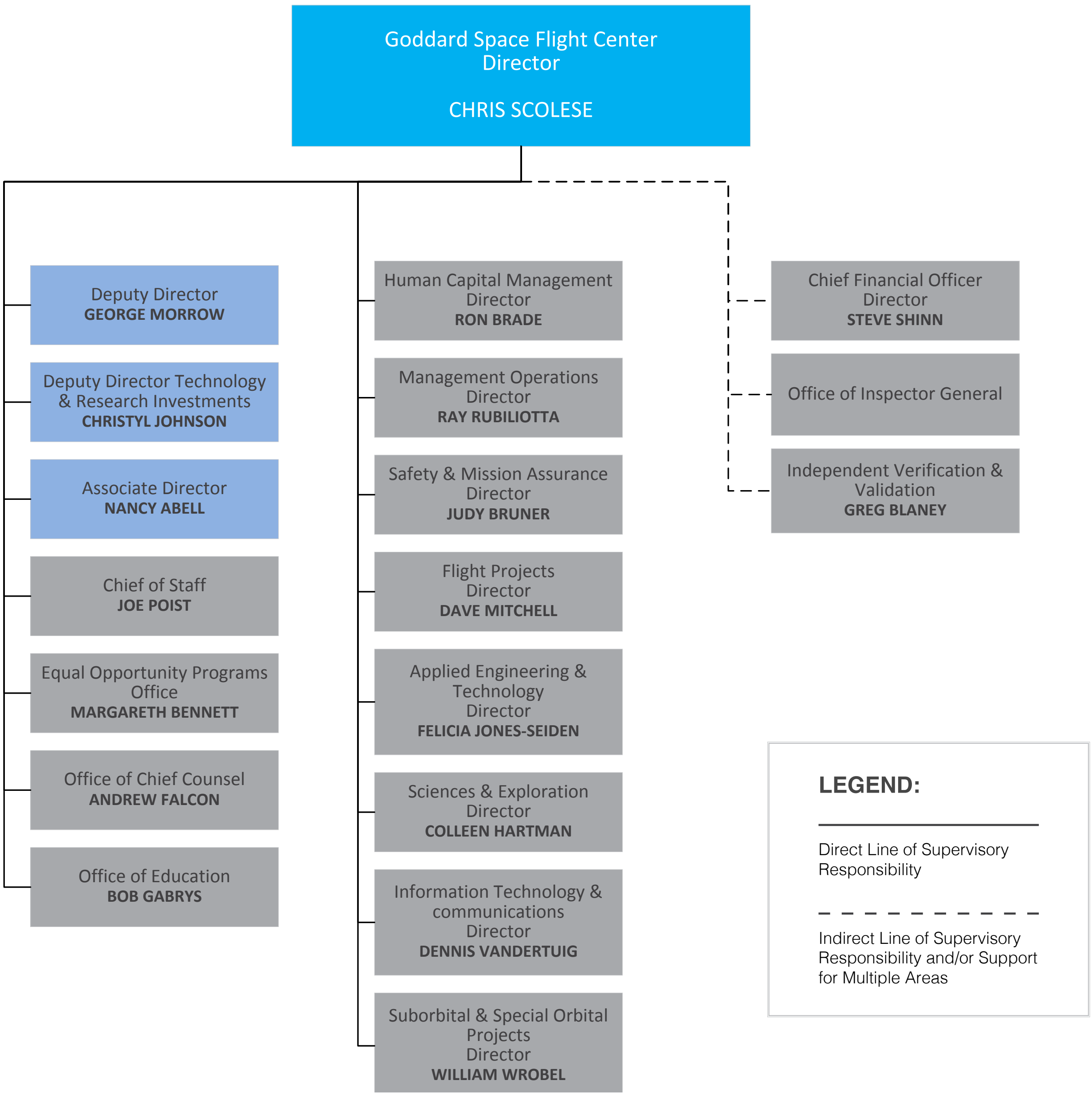


Figure 45.1 Goddard Space Flight Center (GSFC) Organization Chart

CENTER DIRECTOR
MR. CHRISTOPHER SCOLESE

Christopher Scolese is the Center Director of NASA's Goddard Space Flight Center. Scolese assumed his post on March 5, 2012. Scolese previously served as NASA Associate Administrator at NASA Headquarters in Washington, D.C.

As the NASA Associate Administrator, Scolese was responsible for the oversight and integration of NASA's programmatic and technical efforts to ensure the successful accomplishment of the Agency's overall mission. From January 20, 2009, until July 2009, Scolese served as the Acting Administrator of NASA. As the Acting Administrator, he was responsible for leading the development, design, and implementation of the nation's civil space program. As such, Scolese provided overall leadership for NASA's multiple field installations, working closely with the Executive and Legislative branches.
EXTENDED BIO - *http://www.nasa.gov/centers/goddard/about/people/scolese.html*

DEPUTY CENTER DIRECTOR
MR. GEORGE MORROW

George Morrow is the Deputy Director of Goddard Space Flight Center and has served in this position since April 1, 2015. In this position he assists the Director in overseeing all Goddard activities.

From 2007 to 2015, Morrow served as the Director of Flight Projects at Goddard. He was responsible for the day-to-day management of more than 40 Space and Earth Science missions in formulation, implementation, or operation at Goddard as well as management of the Earth Science Technology Office and the Advanced Concepts and Technology Office. Prior to that, Morrow served as the Deputy Director of Flight Projects and in various program and project management positions including in support of Hubble Space Telescope Servicing Missions 1 and 2.
EXTENDED BIO - *http://www.nasa.gov/content/goddard/george-w-morrow-jr-goddard-deputy-center-director*

ASSOCIATE DIRECTOR
MS. NANCY ABELL

Nancy Abell is Goddard's Associate Director. In this role, she has oversight responsibility for all human capital, institutional. and business management activities at the Center. Abell has spent her entire career at Goddard. In 1981, Abell became a Senior Analyst in the Office of the Comptroller, responsible for independent review, assessment and analysis of programmatic and resources requirements for major Goddard programs. In 1990, she was named chief of the Administration and Resources Management Office in the Space Sciences Directorate and served as the Senior Resources Authority for the Directorate. Five years later, Abell was named the Center's Deputy Comptroller.
EXTENDED BIO - *http://www.nasa.gov/centers/goddard/about/people/abell.html*

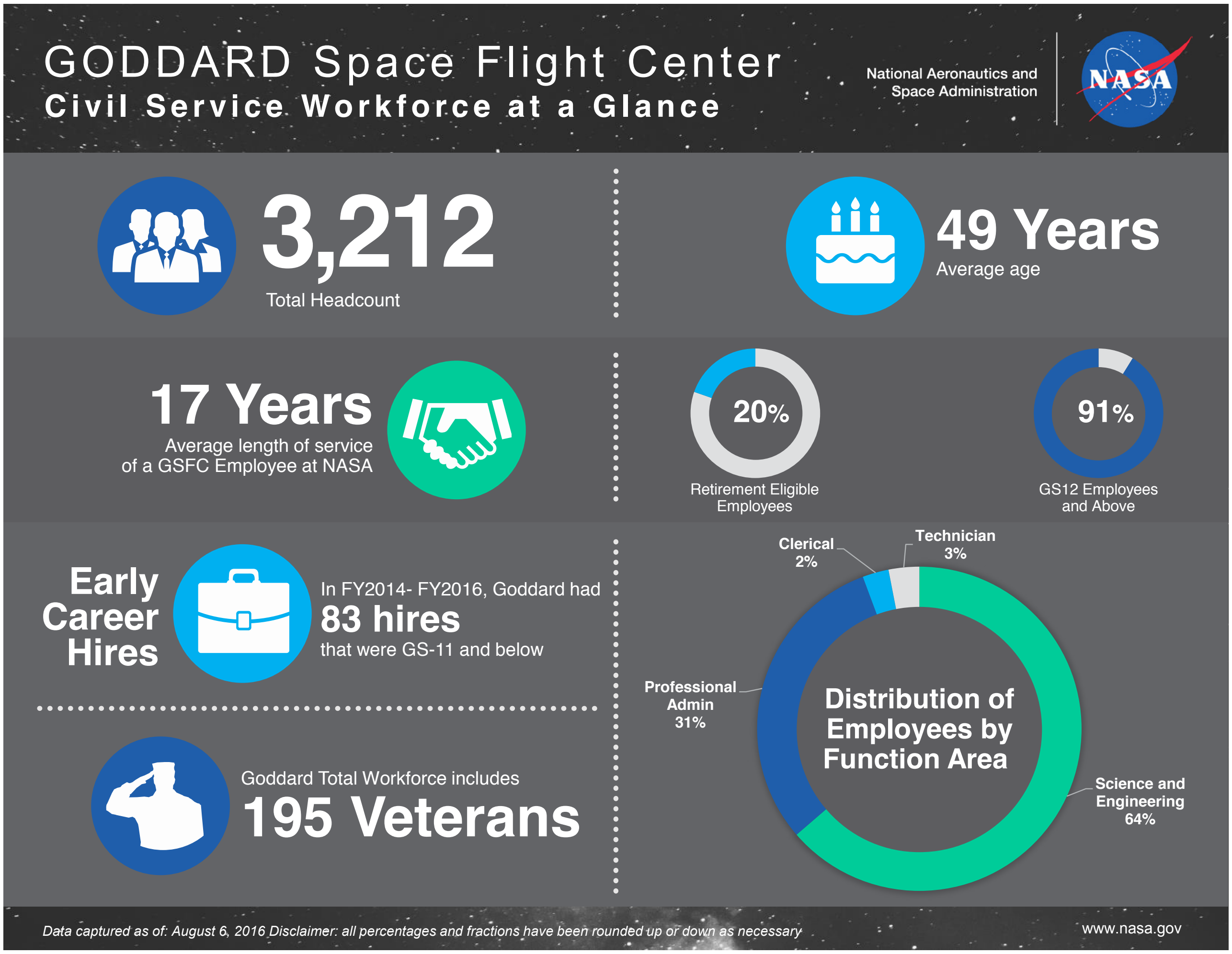


Figure 45.2 Goddard Space Flight Center Workforce at a Glance

ADDITIONAL RESOURCES

- WWW [Goddard Missions - Present]
- WWW [Goddard Missions - Future]
- WWW [Goddard Missions - Past]
- WWW [Goddard Overview]

JET PROPULSION LABORATORY (JPL)

MISSION STATEMENT

The Jet Propulsion Laboratory (JPL) is a Federally Funded Research and Development Center (FFRDC) managed for NASA through a contract with the California Institute of Technology (Caltech). The FFRDC is a unique non-Government entity sponsored and funded by NASA to meet specific long-term technical needs that cannot be met by any other single organization within NASA. As part of this special relationship, it is also required that JPL be operated in the public interest with objectivity and independence, be free from organizational conflicts of interest, and have full disclosure of its affairs to NASA. The NASA Management Office (NMO) is the NASA Headquarters (HQ) on-site Government organization serving the functions of contract management and programmatic and institutional implementation oversight at NASA's contractor-operated FFRDC, and of contract management and oversight at the Applied Physics Laboratory (APL).

CENTER WEBSITE -http://www.jpl.nasa.gov/

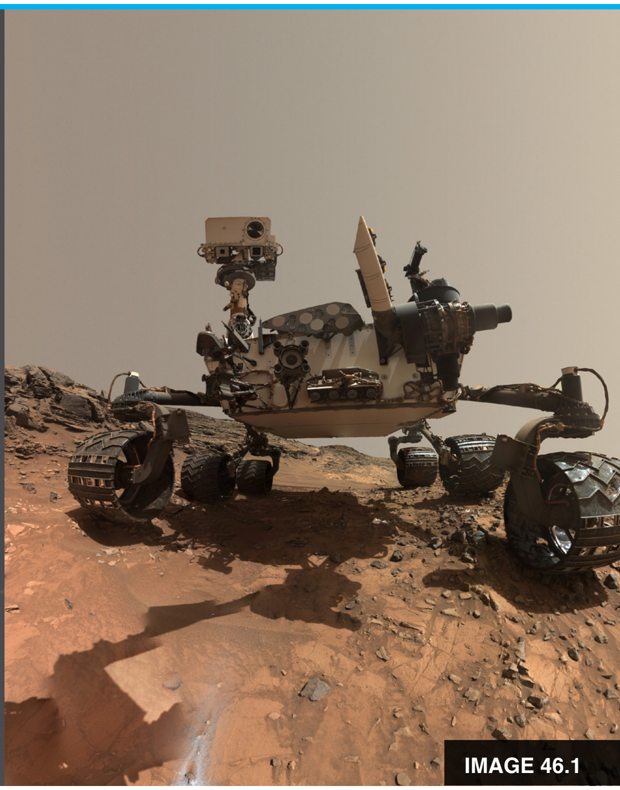


IMAGE 46.1

JET PROPULSION LABORATORY CORE FUNCTIONS

JPL SUPPORTS NASA MISSION DIRECTORATES' PROGRAMS WITH THE FOLLOWING:

- End-to-end space mission architecture, design, implementation and operations (science, technology, system engineering, deep space telecom and navigation).
- Robotic spacecraft and missions, including planetary surface and atmospheric mobile platforms and entry, descent and landing systems.
- Science and science instruments for planetary exploration, earth science and astrophysics.
- Advanced telescopes and large apertures/structures.
- In-space electric propulsion.
- Deep space communications and navigation.

JET PROPULSION LABORATORY DESCRIPTION

JPL's principal facilities are located on 167 acres in La Cañada Flintridge, California, adjacent to Pasadena at the northern end of the Arroyo Seco watershed system. The La Cañada Flintridge/Pasadena Center is known as the Oak Grove Site, after its address on Oak Grove Drive.

Unique key facilities include a 25 foot thermal vacuum chamber with solar capability, a 12,000 square foot class 10K clean room for integration and test of spacecraft, a simulated outdoor Martian landscape (Mars Yard) used to test robotic prototypes, plus on-lab capabilities to fabricate sensors for instruments and full fabrication capability of electrical and mechanical systems for NASA spacecraft.

JET PROPULSION LABORATORY COMPONENT FACILITIES

THE DEEP SPACE NETWORK (DSN)

The DSN encompasses antenna complexes strategically placed on three continents, including the communications stations in Madrid, Spain; Canberra, Australia; and the Goldstone Complex near Barstow, California. The DSN is the largest and most sensitive scientific telecommunications system in the world; it also performs radio and radar astronomy observations for the exploration of the solar system and the universe. JPL is responsible for operating the DSN for NASA.

KEY LABORATORIES AND OFFICES

SCIENCE LABORATORIES

JPL's science laboratories enable research on the nature of the Martian surface, the causes and mitigation of ozone depletion and global warming in Earth's atmosphere, the search for life in and the nature and evolution of the universe - all vital issues related to NASA's mission.

THE MICRODEVICES LABORATORY (MDL)

MDL's 11,000-square-foot-micro/nano fabrication facility enables research, development, and small scale production of: 1) a broad range of devices used in NASA's space science program and 2) other national priorities including electron beam lithography-based optics, semiconductor lasers, visible-UV detectors, infrared focal plane arrays, terahertz devices, superconducting materials and devices and nano and micro systems. JPL installations also include an astronomical and atmospheric observatory at Table Mountain, California, and a launch operations site at Cape Canaveral, Florida.

NASA MANAGEMENT OFFICE (NMO)

NASA's on-site office at JPL. The NMO conducts contract management and provides oversight, on behalf of NASA HQ offices, of programmatic and institutional program implementation at JPL. The NMO also manages NASA's contract with the Johns Hopkins University Applied Physics Laboratory (APL), as well as contracts with the Commonwealth of Australia and the government of Spain for the facilities and operations of NASA's Deep Space Network Communication Complexes.

JET PROPULSION LABORATORY / NASA MANAGEMENT OFFICE ORGANIZATION

The NASA Management Office (NMO) is NASA's on-site office at JPL-FFRDC. NMO conducts contract management and provides oversight, on behalf of NASA HQ offices, of programmatic and institutional program implementation at JPL. NMO has 40 Full Time Equivalent (FTE) employees. JPL is operated pursuant to contract by the California Institute of Technology, and in FY 2015 had 4, 831 Work Year Equivalents (WYE).

The organizational chart provides insight into the official roles and relationships within JPL.

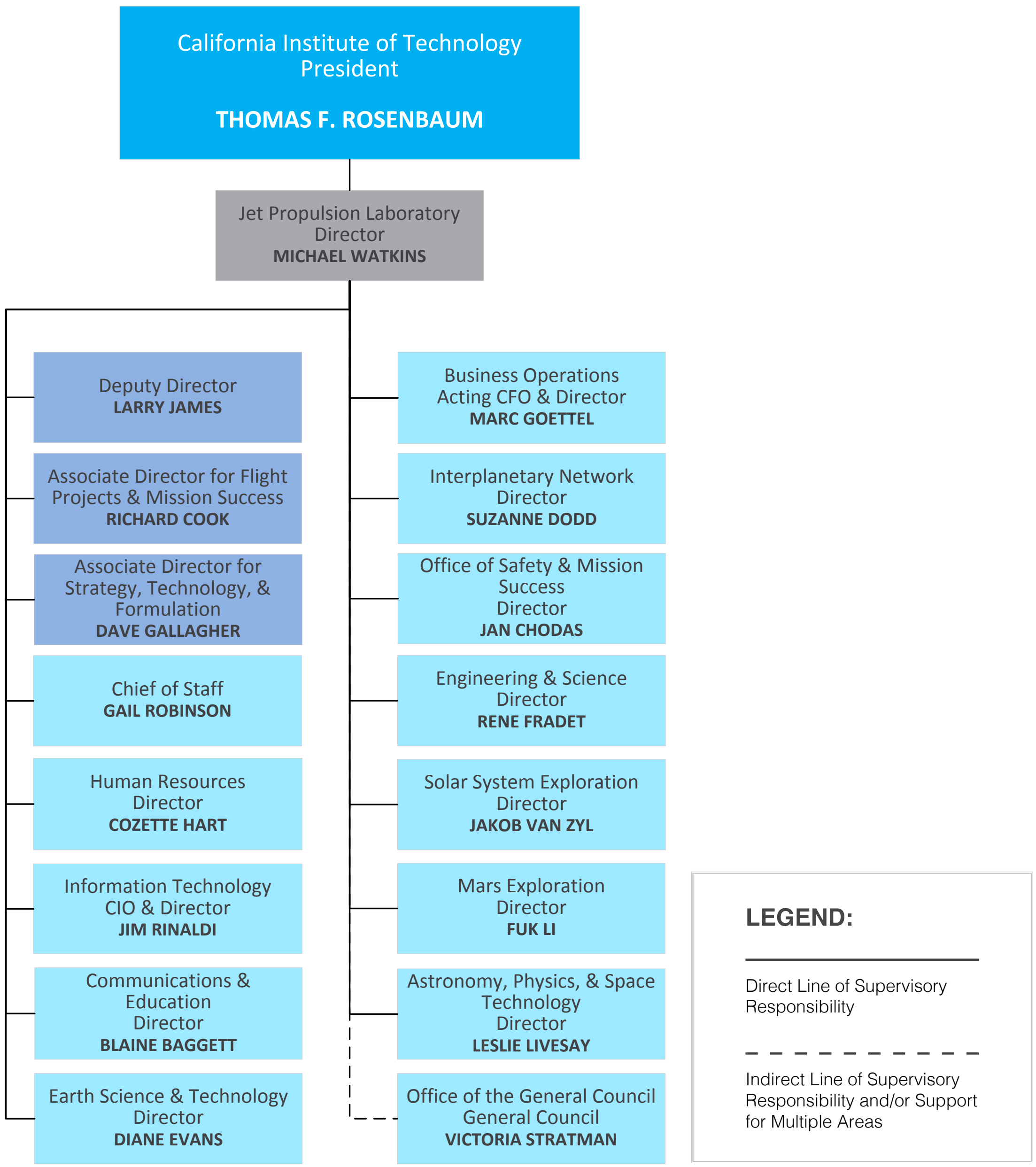


Figure 46.1 Jet Propulsion Laboratory Organization Chart

JET PROPULSION LABORATORY / NASA MANAGEMENT OFFICE ORGANIZATION

The organizational chart provides insight into the official roles and relationships within NMO.

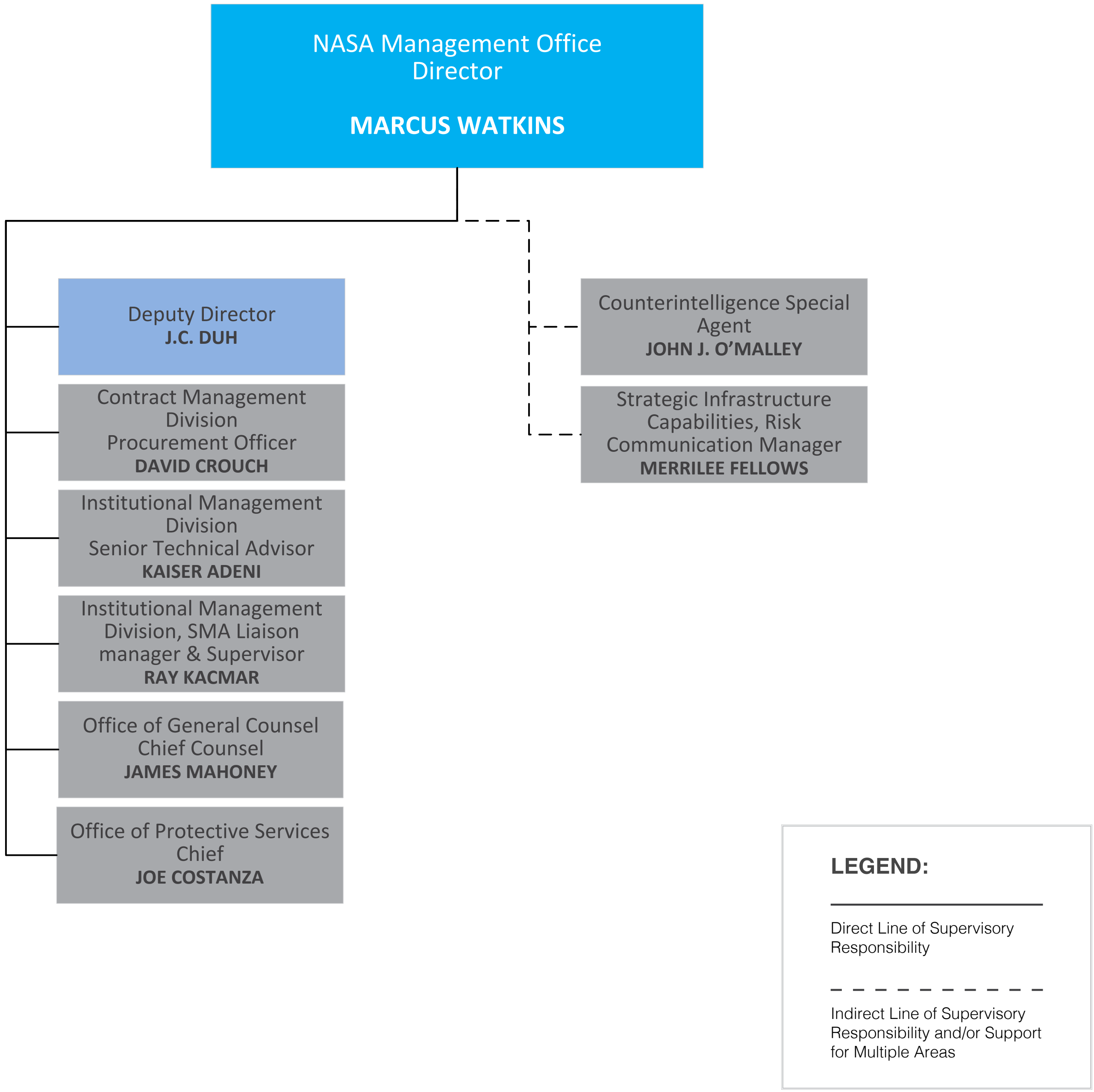


Figure 46.2 NASA Management Office Organization Chart

NMO DIRECTOR
MR. MARCUS WATKINS

Marcus Watkins was appointed the Director of the NASA Management Office (NMO) in March 2014. Previously, he was the Director of the Joint Agency Satellite Division (JASD) within the Science Mission Directorate (SMD) at NASA HQ, and was responsible for the formulation and implementation of reimbursable programs for NASA's partner agencies. He has served over 20 years at NASA in various leadership positions including the Director of Safety and Mission Assurance at GSFC, the Associate Director of the Sun-Earth Connection Division, the NASA representative to Spain, and the Deputy Director of Flight Programs within the then Office of Space Science. He attended George Washington University, and has Engineering and Administration degrees.

NMO DEPUTY DIRECTOR
DR. JEN-CHOW (J.C.) DUH

Jen-Chow (J.C.) Duh became the NMO Deputy Director in November 2015. J.C. has served over 20 years at NASA in various leadership positions including the Deputy Director of the JASD within the SMD at NASA HQ prior to joining NMO, the Associate Chief Information Officer responsible for NASA's integrated IT infrastructure and services, and the Deputy Chief for the Earth Science Technology Office. He also served two years at the National Weather Service where he was responsible for all the major technology infusion and systems development programs. J.C. earned his Ph.D. and Master's degrees in Mechanical Engineering from the University of Michigan, and a Master's degree in Engineering Management from the MIT.

LABORATORY DIRECTOR
DR. MICHAEL M. WATKINS

Michael M. Watkins, an engineer and scientist, became director of JPL on July 1, 2016. In 2015-2016 he spent a year at the University of Texas at Austin, where he held the Clare Cockrell Williams Chair in Engineering and was director of it's Center for Space Research. Previously on the staff of JPL for 22 years, Watkins served in a variety of management roles in both line and project organizations. Watkins holds a Ph.D. degree in Aerospace Engineering from the University of Texas at Austin. He has published widely in both engineering and science and serves or served on the boards of numerous international scientific and engineering societies. In addition, he has taught estimation, filtering theory and system engineering at the University of Texas at Austin and at Caltech.

EXTENDED BIO - *http://www.jpl.nasa.gov/about/bio_watkins.php*

DEPUTY LABORATORY DIRECTOR

MR. LARRY D. JAMES

Larry D. James was appointed Deputy Director of the Jet Propulsion Laboratory in August 2013. He is the Laboratory's Chief Operating Officer responsible for the day-to-day management of JPL's resources and activities. Prior to his retirement from the Air Force, James was the Air Force Deputy Chief of Staff for Intelligence, Surveillance and Reconnaissance at the Pentagon. He was responsible for policy formulation, planning, evaluation, oversight, and leadership of Air Force intelligence, surveillance and reconnaissance capabilities. James received his B.S. in Astronautical Engineering from the US Air Force Academy and his M.S. in Aeronautics and Astronautics from the Massachusetts Institute of Technology. He was also a Draper Fellow at the Charles Stark Draper Laboratory.

EXTENDED BIO - *http://www.jpl.nasa.gov/about/bio_james.php*

ASSOCIATE DIRECTOR

MR. DAVID B. GALLAGHER

David Gallagher was appointed Associate Director for Strategy, Technology, and Formulation in August 2016. Prior to this appointment, he was the Director for Astronomy and Physics. Previously, he was manager of JPL's Advanced Optical Systems Program Office. He also served as the project manager for the Space Interferometry Mission, the Spitzer Space Telescope Project and the Starlight Project. He managed the PMIRR Instrument and Drop Physics Module reflight. He served as the integration and test manager for the WF/PC-2 Instrument, which corrected the spherical aberration for the Hubble Space Telescope. Dave received a B.S. in Electrical Engineering from Purdue University. After working for IBM for several years, he started and ran a software consulting firm until he joined JPL.

EXTENDED BIO - *http://www.jpl.nasa.gov/about/bio_gallagher.php*

ASSOCIATE DIRECTOR

MR. RICHARD COOK

Richard Cook is JPL's Associate Director for Flight Projects and Mission Success. He was appointed to that position in August 2016 after serving as the Deputy Director for Solar System Exploration. In that capacity, he oversaw the development and operations of several JPL missions, including Insight, Dawn, Juno, and Cassini. Prior to that he was Project Manager for the Mars Science Laboratory Mission during development and after the successful landing of the "Curiosity" rover on Mars. He is a veteran of several previous Mars missions including the Mars Exploration Rovers and Mars Pathfinder. Richard began at JPL in 1989 after receiving a B.S. from the University of Colorado and a M.S. from the University of Texas at Austin. He has been awarded three NASA Outstanding Leadership Medals.

EXTENDED BIO - *http://www.jpl.nasa.gov/about/bio_cook.php*

IMAGE 46.2

! ADDITIONAL RESOURCES

- www [JPL Photo Journal]
- www [JPL Education]
- www [MARS Science Laboratory - Curiosity Rover]
- www [JPL NASA's Eyes]
- www [Voyager]

JOHNSON SPACE CENTER (JSC)

MISSION STATEMENT

On behalf of the Agency Johnson Space Center (JSC)'s mission is to lead human space exploration for the Agency, with the current focus on four priorities: maximizing use of the International Space Station (ISS), enabling success of the Commercial Crew Program, developing the Orion spacecraft for future missions, and building the foundation for human missions to Mars. The core functions needed to carry out this mission are listed in the next section and, broadly stated, encompass design, development, test and evaluation of human spacecraft including related technology development; plan, train for, and fly human space missions; maintain human health and performance in space; and manage large, complex programs, all of which require a comprehensive understanding of space and planetary environments.

JSC manages the ISS Program, the Orion Program, and the Human Research Program (HRP), and partners with the Kennedy Space Center to manage the Commercial Crew Program (CCP). Through both program management and technology development activities, JSC manages a wide range of innovative partnerships with international, commercial, academic, and U.S. Government entities.

CENTER WEBSITE - *https://www.nasa.gov/centers/johnson/home/*
YEAR IN REVIEW VIDEO - *https://m.youtube.com/watch?v=metJZuLJiy4*

IMAGE 47.1

JOHNSON SPACE CENTER CORE FUNCTIONS

HUMAN SPACECRAFT DESIGN, DEVELOPMENT, TEST, AND EVALUATION

Enabled through engineering discipline expertise, systems engineering and integration skills, and facilities. Capability includes development of crew equipment, and technology development for future human missions.

HUMAN SPACEFLIGHT OPERATIONS

Planning, training, and flying human spaceflight missions including selecting astronauts.

HUMAN HEALTH AND PERFORMANCE IN SPACE

Enabling astronauts to perform in space, covering the full range from clinical work to research on health risks to mitigation of those risks, including leadership of the Human Research Program.

HUMAN SPACEFLIGHT PROGRAM MANAGEMENT

Enabling success of large, complex human spaceflight programs including managing partnerships across NASA Centers, with international space agencies, and with commercial companies. In addition to current programs, JSC has previously led all human spaceflight programs since Gemini including Apollo, Skylab, Apollo-Soyuz, Space Shuttle, and Constellation.

HUMAN MISSION ARCHITECTURE ANALYSIS AND DEVELOPMENT

Leveraging Agency strategic roadmaps, human space exploration architecture assumptions, and various exploration strategies to identify, analyze, model, and integrate options for human exploration missions.

SAFETY AND MISSION ASSURANCE

Enabling human space missions through safety, reliability, quality, and risk assessment throughout the lifecycle of human space flights programs.

SPACESUIT DEVELOPMENT AND OPERATIONS

Enabling extravehicular activities (spacewalks) by astronauts and emergency life support within a spacecraft.

ASTROMATERIALS RESEARCH AND CURATION

Combining curatorial responsibility of all NASA-held extraterrestrial samples, including moon rocks, with unique sample science capabilities.

IMAGE 47.2

JOHNSON SPACE CENTER DESCRIPTION

The Johnson Space Center (JSC/Johnson) is NASA's premier Center for human space exploration operations, program management, and spacecraft design, development, test, and evaluation. JSC opened in 1963 in the Clear Lake area of Houston, Texas, on 1,600 acres of land donated through Rice University. Additional aircraft and testing assets are located a few miles away at Ellington Field (228 acres reserved for military and NASA use). The Center houses eight Leadership in Energy and Environmental Design (LEED) certified buildings, including a LEED Platinum building. NASA's first Combined Heat and Power facility will open at JSC in 2017 to support energy efficiency.

JSC also manages the White Sands Test Facility (WSTF) near Las Cruces, NM. Established in 1963 on the White Sands Missile Range, the WSTF, covering 28 square miles (approximately 18,000 acres), is a unique resource for testing and evaluating hazardous materials, space flight components, and in-space rocket propulsion systems.

JOHNSON SPACE CENTER NOTABLE AND UNIQUE FACILITIES

CHRISTOPHER KRAFT MISSION CONTROL CENTER (MCC)

The JSC Mission Control Center (MCC) manages real-time operations of human spaceflight missions. MCC conducted operations of legacy NASA human space programs including Gemini, Apollo, and the Space Shuttle, and currently hosts operations of the International Space Station. The MCC will host upcoming commercial crew Boeing Starliner operations and Orion exploration missions.

NEUTRAL BUOYANCY LABORATORY (NBL)

The Neutral Buoyancy Laboratory (NBL) facility contains unique facilities for astronaut extravehicular (spacewalk) training including a large pool used to provide a neutrally-buoyant environment. This facility includes high fidelity engineering mockups of key spacecraft elements to facilitate training in a simulated weightless environment.

SPACEFLIGHT VEHICLE MOCKUP FACILITY (SVMF)

The Spaceflight Vehicle Mockup Facility (SVMF) contains high fidelity engineering mockups and simulation facilities for key operational spacecraft and mission equipment. SVMF simulators support astronaut training and engineering activities, including mission training and emergency training.

THERMAL VACUUM TEST COMPLEX

The Thermal Vacuum Test Complex is comprised of test chambers of varying sizes that provide for high vacuum, low temperature testing of large spacecraft with and without crew. The largest of these, the 50 foot diameter Chamber A, is currently being utilized for the James Webb Space Telescope. A variety of smaller chambers also provide integrated/altitude/environmental space testing.

HUMAN HEALTH AND PERFORMANCE LABORATORY

The Human Health and Performance Laboratory provides biomedical and environmental science laboratories to support human health and performance in the areas of immunology, anthropometry, exercise, toxicology, nutrition, microbiology, food, cardiovascular, neurovestibular, radiation, and pharmacology.

ASTROMATERIALS CURATION FACILITY

The Astromaterials Curation Facility maintains all of NASA's astromaterials samples including the Apollo lunar sample lab. The facility is responsible for the curation of extraterrestrial samples from NASA's past and future sample return missions and enables the documentation, preservation, preparation, and distribution of samples from the Moon, asteroids, comets, the solar wind, and the planet Mars.

JOHNSON SPACE CENTER ORGANIZATION

In support of JSC's mission to lead human space exploration, JSC's organizational structure aligns to the three major human spaceflight programs: ISS, Commercial Crew, and Orion. The technical organizations contain the core capabilities needed to design, develop, test, and evaluate human spacecraft, and to plan, train for, and fly human space missions, including selecting the country's astronauts and maintaining human health and performance in space.

Because of JSC's leadership role in human spaceflight programs, the mission support organizations, while standard in basic functions to all Centers, have specialized expertise in international partnerships; a range of public/private partnerships including commercial, academia, and other government agencies; and outreach and education with astronauts.

The Center organizational chart provides insight into the official roles and relationships within JSC.

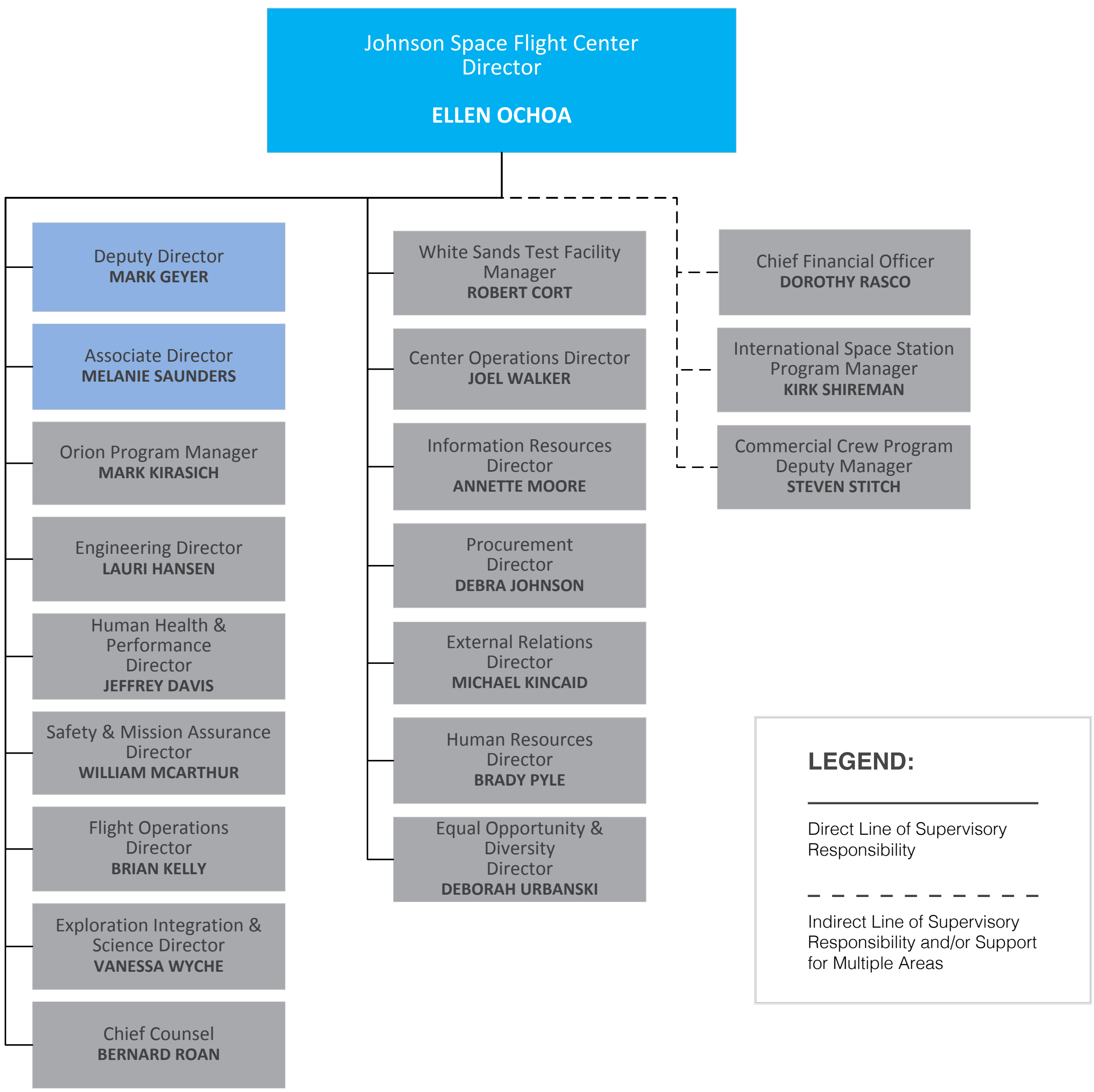


Figure 47.1 Johnson Space Center (JSC) Organization Chart

CENTER DIRECTOR
DR. ELLEN OCHOA

Dr. Ellen Ochoa, a veteran astronaut, became Johnson Space Center's 11th director in January 2013. She joined NASA in 1988 as a Research Engineer at Ames Research Center, and moved to Johnson Space Center in 1990 when she was selected as an astronaut. She flew on four space shuttle missions, becoming the first Hispanic woman to go to space in 1993. Ochoa's previous management roles include Director of Flight Crew Operations and Deputy Center Director. She is a Fellow of the American Association for the Advancement of Science (AAAS) and the American Institute of Aeronautics and Astronautics (AIAA), and also chairs the Nomination Evaluation Committee for the National Medal of Technology and Innovation.
EXTENDED BIO - *http://www.nasa.gov/centers/johnson/about/people/orgs/bios/ochoa.html*

DEPUTY CENTER DIRECTOR
MR. MARK S. GEYER

Mark Geyer assists in management of Johnson Space Center, including White Sands Test Facility in Las Cruces, NM, overseeing a broad range of human spaceflight activities. Prior to being named Deputy Center Director, Geyer served as Manager of the Orion Program, beginning in 2007. Under Geyer's direction, Orion was successfully tested in space in 2014. Geyer also served as Deputy Program Manager of the Constellation Program from 2004 to 2007. In 1999, he became an Increment Manager for the International Space Station, responsible for integrating operations requirements between NASA, the Russian Space Agency and their contractors prior to arrival of the first International Space Station crew.
EXTENDED BIO - *http://www.nasa.gov/centers/johnson/about/people/orgs/bios/deputydirector.html*

ASSOCIATE DIRECTOR
MS. MELANIE W. SAUNDERS

Melanie W. Saunders helps to manage the Johnson Space Center and supervises White Sands Test Facility in Las Cruces, NM. As Associate Director, Saunders oversees a broad range of human spaceflight activities. Prior to being named Associate Center Director, Saunders served as Associate Manager of the International Space Station (ISS) Program from 2005 to 2009 during the most intensive phases of ISS assembly. From 2003 to 2005, she was Deputy Manager of the ISS External Relations Office. Saunders joined NASA in 1994, beginning her career as the manager for International Policies for the International Space Station Program negotiating international agreements.
EXTENDED BIO - *http://www.nasa.gov/centers/johnson/about/people/orgs/bios/associatedirector.html*

JOHNSON SPACE CENTER AT A GLANCE

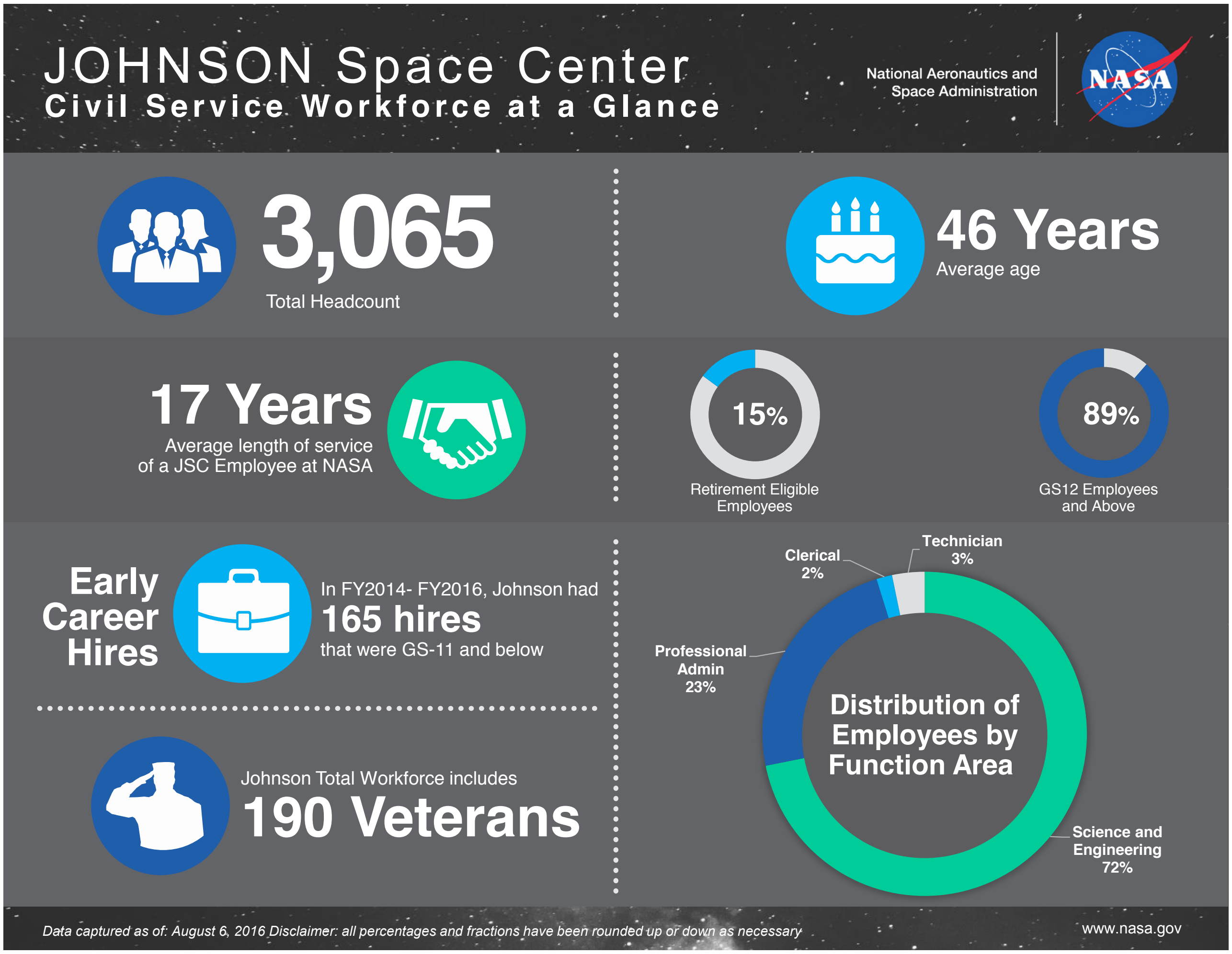


Figure 47.2 Johnson Space Center Workforce at a Glance

ADDITIONAL RESOURCES

- www [International Space Station Program]
- www [Orion Spacecraft Program]
- www [Commercial Crew Program]
- [FY15 JSC Economic Impact Report]
- www [WSTF Homepage]
- www [JSC Facebook]

KENNEDY SPACE CENTER (KSC)

MISSION STATEMENT

On behalf of the Agency Kennedy Space Center (KSC) is responsible for the preflight processing, launch, landing, and recovery of the Agency's human-rated spacecraft and launch vehicles; the assembly, integration, and processing of International Space Station (ISS) elements and flight experiments; the acquisition and management of launch services for Agency spacecraft; and leading the development of a commercial crew transportation system for access to and from low Earth orbit and the ISS. KSC leads the development of ground systems supporting human-rated spacecraft and launch vehicles and lunar *in situ* resource utilization hardware elements. KSC hosts the manufacturing of the Orion spacecraft. KSC executes research and technology projects in support of Agency exploration initiatives and establishes partnerships with commercial and other governmental entities to optimize the use of KSC capabilities and facilities to establish a multiuser spaceport.

CENTER WEBSITE - *http://www.nasa.gov/centers/kennedy/home/index.html*

IMAGE 48.1

KENNEDY SPACE CENTER CORE FUNCTIONS

ACQUISITION AND MANAGEMENT OF LAUNCH SERVICES AND COMMERCIAL CREW DEVELOPMENT

Provides safe, reliable, and cost-effective launch services for NASA and NASA-sponsored payloads requiring access to space via expendable launch vehicles. Facilitates development of a U.S. commercial crew space transportation capability.

LAUNCH VEHICLE AND SPACECRAFT PROCESSING, LAUNCH, LANDING, RECOVERY, OPERATIONS, AND SUSTAINING

Leads and performs these tasks in support of the Agency's human-rated spacecraft and launch vehicles.

PAYLOAD AND FLIGHT SCIENCE EXPERIMENT PROCESSING, INTEGRATION, AND TESTING

Performs ground processing support for associated research and flight experiments. Delivers time-critical launch or landing site payload customer services.

DESIGNING, DEVELOPING, OPERATING, AND SUSTAINING FLIGHT AND GROUND SYSTEMS AND SUPPORTING INFRASTRUCTURE

Develops ground systems infrastructure to support assembly, test, launch, and recovery of Space Launch System (SLS) and Orion elements.

DEVELOPMENT, TEST, AND DEMONSTRATION OF ADVANCED FLIGHT SYSTEMS AND TRANSFORMATIONAL TECHNOLOGIES TO ADVANCE EXPLORATION AND SPACE SYSTEMS

Leads the development of applied technologies and systems required to improve processing and launch systems.

KENNEDY SPACE CENTER DESCRIPTION

The Kennedy Space Center (KSC or Kennedy) is located along Florida's east central coast about halfway between Miami and Jacksonville, in an area known as the Space Coast. It shares a boundary with the Merritt Island National Wildlife Refuge that includes 140,000 acres of land, water, and marshes. KSC has over 50 years of experience in design, development, and operation of payload/spacecraft processing and launch systems used to support human spaceflight and robotic missions. KSC has recently transformed itself from a Government-only launch site to a multiuser spaceport supporting government and commercial providers. KSC currently has over 80 active partnerships that include four separate human spaceflight programs. KSC facilities have been made available for use by commercial and other government space-related organizations including; Pad-A (former Shuttle Launch Pad 39A), the Shuttle Landing Facility (SLF), the three Orbiter Processing Facility (OPF) high bays, a high bay in the Vehicle Assembly Building (VAB), and several other smaller facilities and labs.

KENNEDY SPACE CENTER NOTABLE AND UNIQUE FACILITIES

VEHICLE ASSEMBLY BUILDING

Used to assemble and house American-crewed launch vehicles from 1968 to 2011. The building is being modified to support NASA's Space Launch System (SLS) and is also capable of supporting other commercial customers at the same time.

LAUNCH PAD 39B

Built as one of two identical launch pads for the enormous Saturn V moon rocket, Pad B was restructured for Space Shuttle launches and modified for the launch of an Ares I-X test vehicle in 2009. It is being modified again, this time to host several different kinds of launch vehicles, including the SLS.

LAUNCH CONTROL CENTER

As the hub of launch operations at NASA's Kennedy Space Center in Florida since the Apollo program, the Launch Control Center (LCC) has played an integral role in NASA's human spaceflight programs for over 50 years. The LCC firing rooms are being modified to oversee launches and preparations of a new generation of rockets and spacecraft like the SLS.

ORION FACILITIES

The assembly, integration, and testing of NASA's Orion spacecraft program requires numerous facilities at Kennedy for preflight and post flight processing following three decades of work supporting the Space Shuttle fleet, such as the Neil Armstrong Operations and Checkout Building High Bay, Launch Abort System Facility (LASF), and Multi-Payload Processing Facility (MPPF).

LAUNCH EQUIPMENT TEST FACILITY

This facility provides NASA with a proving ground to safely assess machinery and designs intended to support the launches of the biggest rockets ever built.

SPACE STATION PROCESSING FACILITY

The 457,000 square foot, three-story building includes two processing bays, an airlock, operational control rooms, laboratories, logistics areas, and office space. It was built specifically for processing the International Space Station (ISS) flight hardware, but other commercial customers are also now using this facility.

SWAMP WORKS

This laboratory provides a hands-on lean development environment for innovation regarding development of surface systems at any space destination.

KENNEDY SPACE CENTER ORGANIZATION

KSC is organized to provide program, technical, and institutional support to successfully accomplish mission objectives. Program leadership manages the Launch Services Program, Commercial Crew Program, Ground Systems Development and Operations Program, and the Exploration Research and Technology Programs for the Agency. The technical and business services units support Center and program leadership and consist of Engineering, Information Technology and Communications Services, Safety and Mission Assurance, Spaceport Integration and Services, Office of the Chief Financial Officer, Communication and Public Engagement, Procurement, Human Resources, Office of Diversity and Equal Opportunity, and Office of the Chief Counsel. An organization unique to KSC is the Center Planning and Development (CPD) Directorate. CPD is responsible for leading the effort to evolve KSC as the world's preeminent multiuser spaceport.

The Center organizational chart provides insight into the official roles and relationships within KSC.

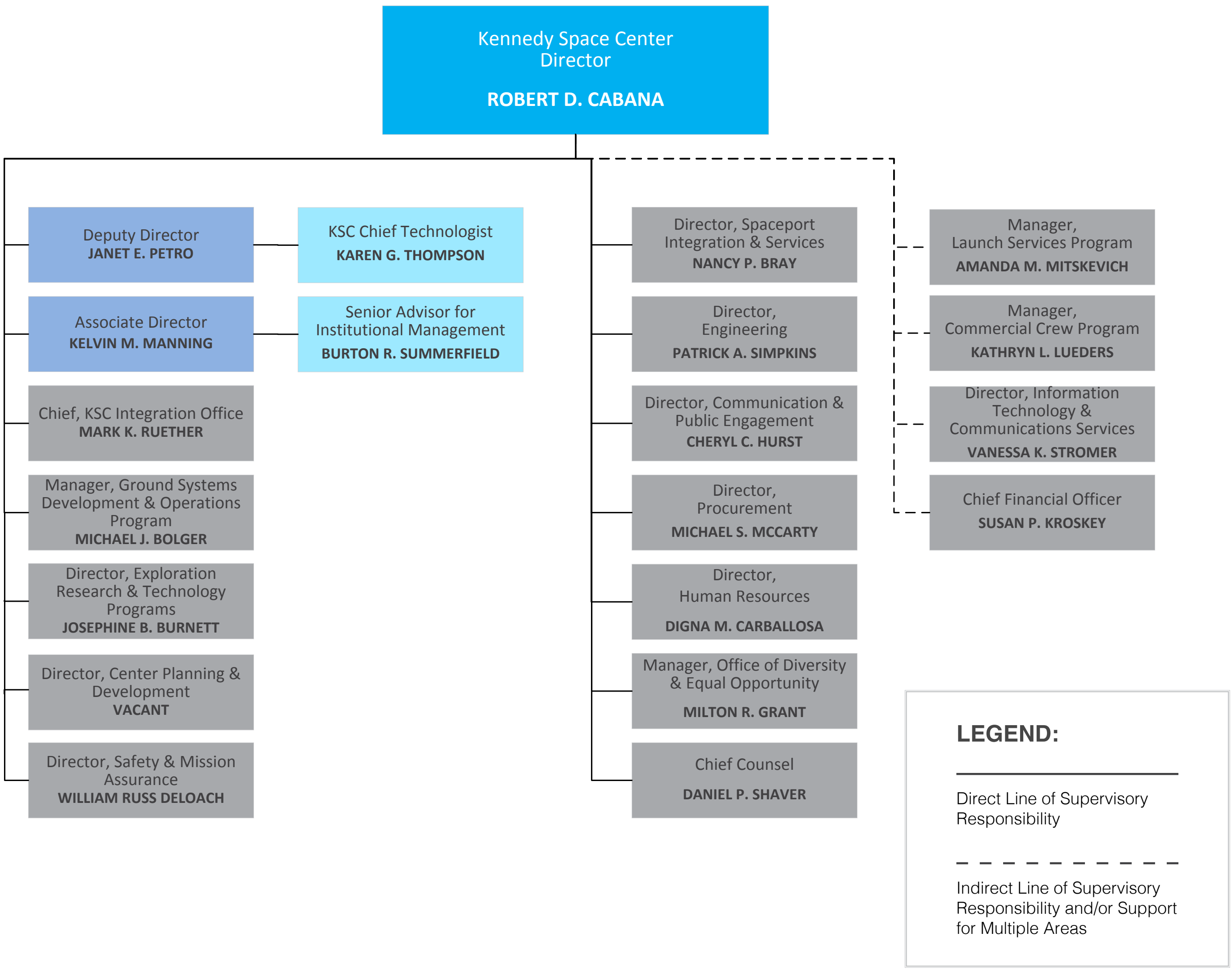


Figure 48.1 Kennedy Space Center (KSC) Organization Chart

DIRECTOR

MR. ROBERT D. CABANA

Mr. Robert D. Cabana, a former NASA astronaut, currently serves as Director of NASA's KSC. As Center Director, Cabana manages all NASA facilities and activities at the spaceport, including the civil service and contractor employees who operate and support numerous space programs and projects. A veteran of four space flights, Cabana logged 38 days in space. Following his retirement as a Marine Corps colonel in September 2000, Cabana was appointed a member of the Federal Senior Executive Service. He served in numerous challenging senior management positions at Johnson Space Center, ultimately becoming Deputy Director. In October 2007, Cabana was appointed Director of NASA's John C. Stennis Space Center, and a year later was reassigned as the tenth Director of the Kennedy Space Center.
EXTENDED BIO - *http://www.nasa.gov/centers/kennedy/about/biographies/cabana.html*

DEPUTY DIRECTOR

MS. JANET E. PETRO

Appointed Deputy Director in April 2007, Janet Petro shares responsibility with the Center Director in managing the civil service and contractor workforce, Center policy, and executing Kennedy missions and Agency program responsibilities. She began her career as a commissioned officer in the U.S. Army's aviation branch after graduating from the U.S. Military Academy at West Point with a Bachelor of Science in Engineering. She also holds a Master of Science in Business Administration from Boston University's Metropolitan College. Prior to joining NASA, Petro served in management positions for Science Applications International Corporation and McDonnell Douglas Corporation, where she held multiple engineering and management positions supporting numerous aerospace and military programs.
EXTENDED BIO - *http://www.nasa.gov/centers/kennedy/about/biographies/petro.html*

ASSOCIATE DIRECTOR

MR. KELVIN M. MANNING

Mr. Kelvin M. Manning serves as Associate Director of NASA's KSC. In this capacity, Mr. Manning is responsible for oversight of Kennedy's institutional business and technical support functions, planning, directing, and coordinating Center policy on a day-to-day basis. This includes establishing strategies and procedures to ensure the Kennedy workforce, facilities, and operations are aligned to meet Agency program and project goals. A former Air Force officer, Mr. Manning began his career at Kennedy in 1992 and has served in a number of positions, including Flow Director for Space Shuttle Atlantis, Chief Engineer (acting) for Shuttle Upgrades, Vehicle Manager for Space Shuttle Columbia, NASA Test Director, and Orion Division Chief in the Kennedy Constellation Project Office.
EXTENDED BIO - *http://www.nasa.gov/centers/kennedy/about/biographies/manning.html*

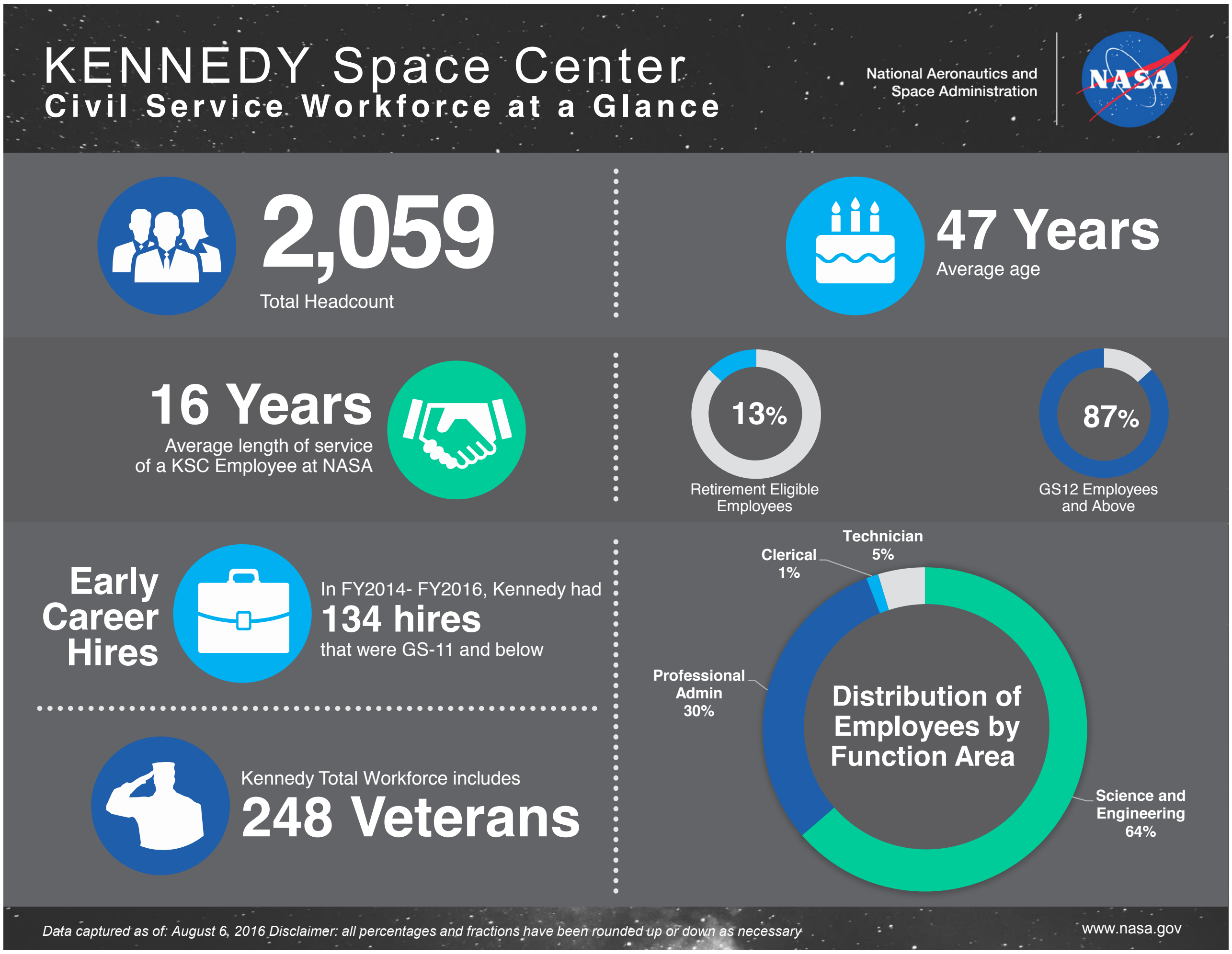


Figure 48.2 Kennedy Space Center Workforce at a Glance

ADDITIONAL RESOURCES

- [Kennedy Space Center, External Web Page]
- [Launch Services Program]
- [Commercial Crew Program]
- [Ground Systems Development and Operations Program]
- [Exploration Research and Technology Programs]

LANGLEY RESEARCH CENTER (LaRC)

MISSION STATEMENT

On behalf of the Agency NASA Langley is a research, science, technology, and development Center that provides game-changing innovations to enable NASA to make significant contributions to the nation. The Center is recognized as a leader in systems innovation for expanding air mobility, exploring space, and definitively characterizing the Earth's changing climate. Langley's work spans fundamental research to mission development and operations with an eye toward the next generation of cutting-edge ideas that provide new capabilities or significantly improve performance or cost.

CENTER WEBSITE - *https://www.nasa.gov/langley*
YEAR IN REVIEW VIDEO - *https://www.youtube.com/watch?v=29q-GsqPsTA*

IMAGE 49.1

LANGLEY RESEARCH CENTER CORE FUNCTIONS

ADVANCED MATERIALS AND STRUCTURAL SYSTEMS
Develop new materials, space-based manufacturing technologies, structural concepts, design/analysis tools and certification methods for aircraft, spacecraft, space habitats, and sensor systems.

AEROSCIENCES
Provide design tools and innovative technologies to enable the development of advanced aircraft and space access concepts.

ATMOSPHERIC CHARACTERIZATION
Design and execute missions that collect data on Earth's atmosphere, answering vital science questions about our planet.

ENTRY, DESCENT, AND LANDING
Improve methods of traveling through a planet's atmosphere and safely landing large payloads, a key step toward putting humans on Mars.

INTELLIGENT FLIGHT SYSTEMS
Develop, validate and test (ground, flight and virtual) new flight technologies, vehicles, and operating concepts to enhance and create integrated flight systems.

MEASUREMENT SYSTEMS
Contribute to the development of measurement systems for ground test and space flight, examples include aerodynamic flow diagnostics, structural diagnostics, and Earth radiation budget.

SYSTEMS ANALYSIS AND CONCEPTS
Arm decision makers with the information and understanding they need by examining missions, vehicles, advanced systems, technologies, cost, and risk.

LANGLEY RESEARCH CENTER DESCRIPTION

The Langley Research Center (LaRC/Langley) is a truly unique place that has experienced continued growth since becoming the nation's first civilian aeronautical research laboratory in 1917. Based in Hampton, VA, it spans approximately 764 acres and directly borders the Air Force Joint Base Langley-Eustis.

Langley's facilities enable space exploration, aeronautics, and science to conduct experimentation, testing, and validation from concept to flight needed to advance next-generation aerospace technologies. The Center has more than 150 facilities including wind tunnels, laboratories, and energy-efficient office space. Langley is also home to the NASA Engineering and Safety Center (NESC) which performs value-added independent testing, analysis, and assessments of NASA's high-risk projects to ensure safety and mission success.

Langley continues to implement a comprehensive 20-year revitalization plan that will ultimately result in seven new buildings, two renovated facilities, and the phased removal of deteriorated and underused facilities, significantly driving down annual operations and maintenance costs.

LANGLEY RESEARCH CENTER NOTABLE AND UNIQUE FACILITIES

AEROSCIENCE GROUND TEST FACILITIES

Langley is home to many aeroscience ground test facilities including the National Transonic Facility (NTF), Transonic Dynamics Tunnel (TDT), 20-Foot Vertical Spin Tunnel (VST), 8-Foot High Temperature Tunnel (HTT), 14' x 22' Subsonic Wind Tunnel, the Combined Loads Test System (COLTS), and the Langley Aerothermodynamics Laboratory (LAL). These facilities have a rich history of significant design contributions for many commercial transports, launch vehicles, military aircraft, and spacecraft. The unique capabilities of each of these facilities play a critical role for NASA and in the development of future commercial and military aircraft, commercial space and advanced subsonic, supersonic, and hypersonic vehicles.

CITY ENVIRONMENT FOR RANGE TESTING OF AUTONOMOUS INTEGRATED NAVIGATION (CERTAIN)

CERTAIN is an FAA approved urban environment drone test range allowing researchers to reduce the risk of integrating unmanned aircraft systems into our national airspace.

AIR TRAFFIC OPERATIONS LABORATORY (ATOL)

ATOL is used to test technologies to help improve air traffic management.

INTEGRATED STRUCTURAL ASSEMBLY OF ADVANCED COMPOSITES (ISAAC)

ISAAC is a state-of-the-art robot with an important role in developing lighter, stronger advanced composite structures and materials for aerospace vehicles.

LANDING AND IMPACT RESEARCH FACILITY (LANDIR)

LandIR is a 240-foot high, 400-foot-long, 265-foot-wide A-frame steel gantry used for testing and analyzing the structural integrity of aircraft, rotorcraft and, most recently, the Orion Crew Exploration Vehicle.

AEROSPACE FLIGHT HARDWARE ASSEMBLY AND INTEGRATION FACILITY AND THE FLIGHT RESEARCH FACILITY

These facilities are critical in facilitating NASA Langley's Atmospheric Characterization work, which includes scientific missions that collect data on Earth's atmosphere, answering vital questions about our planet.

LANGLEY RESEARCH CENTER ORGANIZATION

The Office of the Director (OD) includes the Director, Deputy Director, and Associate Director. The OD is supported by the Office of Strategic Analysis, Communications, and Business Development. The Center has a unique, relatively flat organizational structure.

The Center's mission-facing organizations include Science, Aeronautics, and Space Technology and Exploration which are facilitated through Flight Projects, Systems Analysis and Concepts, Engineering, and Research. Additionally, Mission Support ensures the availability of facilities, tools, and services needed to conduct NASA's missions. These include safety, Center operations, procurement, chief counsel, equal opportunity, human capital, finance, and information technology.

The Center organizational chart provides insight into the official roles and relationships within NASA Langley.

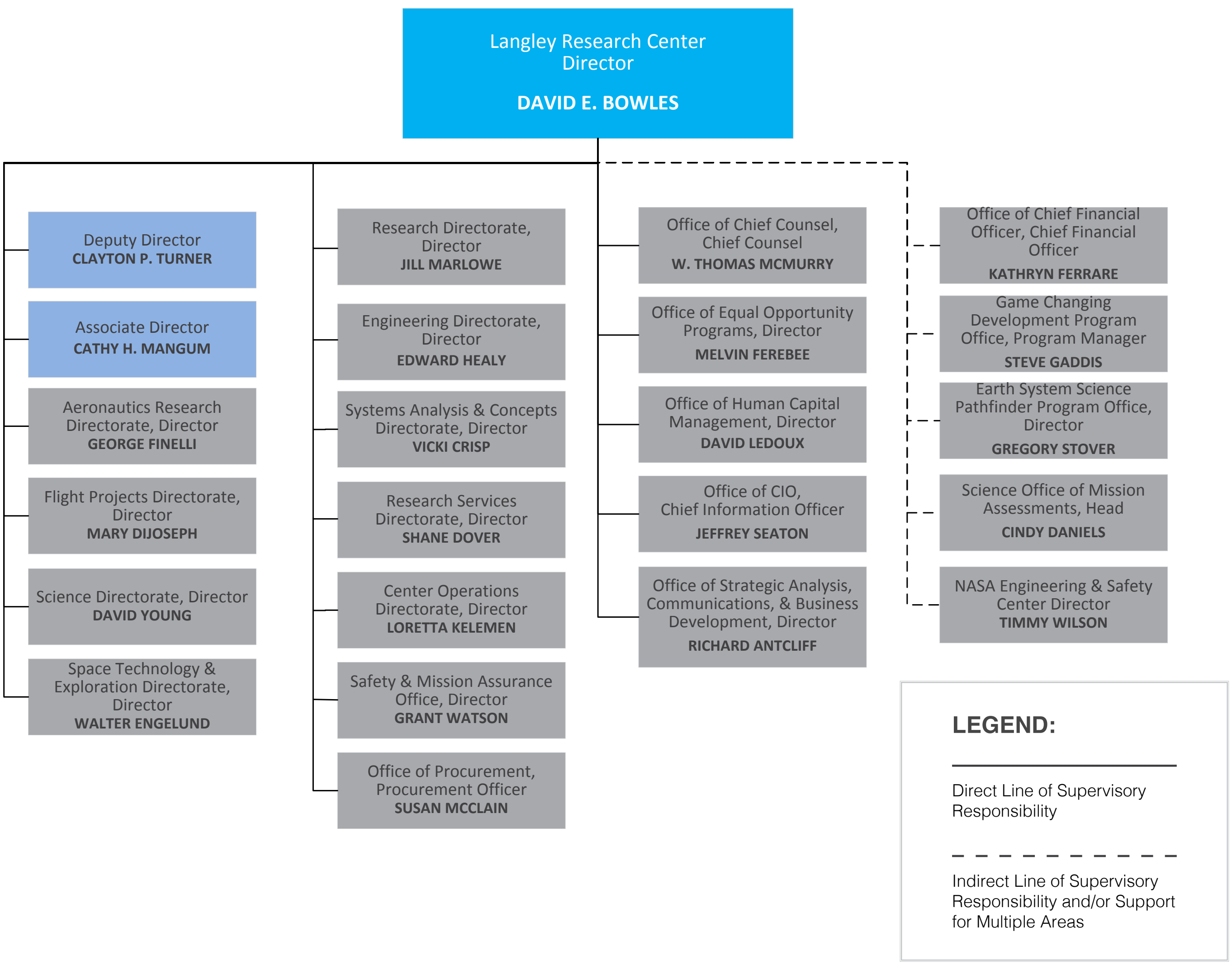


Figure 49.1 Langley Research Center (LaRC) Organization Chart

CENTER DIRECTOR
DR. DAVID E. BOWLES

Dr. Bowles joined the Director's Office in March 2012 as Associate Director, progressed to Deputy Director in 2014 and then served as Acting Center Director until he permanently moved into the role in June 2015.

Dr. Bowles has been an active member of the NASA Langley community for more than 35 years, serving in several roles, including Director of Langley's Exploration and Space Operations Directorate, Manager for Airframe Structures Integrity and Vehicle Systems Research and Technology Project Manager, allowing for program and project management experience across aeronautics and space-related activities.

Dr. Bowles earned his Bachelor's, Master's and Doctoral degrees in Engineering Mechanics from Virginia Tech in 1978, 1980 and 1990, respectively. He received NASA's Outstanding Leadership Medal twice.

EXTENDED BIO *- https://www.nasa.gov/feature/langley/dr-david-e-bowles*

DEPUTY CENTER DIRECTOR
MR. CLAYTON P. TURNER

Mr. Turner joined the Director's Office in 2015. He previously served as NASA Langley's Associate Director, Director of the Engineering Directorate, and Chief Engineer.

After graduation from the Rochester Institute of Technology in 1990, Mr. Turner began his career with NASA as a Design Engineer with the Lidar In-Space Technology Experiment project. Over the next 24 years, Clayton served in various roles leading engineering contributions to many successful flight projects.

Throughout his career, he has received many prestigious awards including the NASA Outstanding Leadership Medal, the NASA Exceptional Engineering Achievement Medal, and the Paul F. Holloway Non-Aerospace Technology Transfer Award. He is an Associate Fellow of the AIAA.

He is passionate about promoting Science, Technology, Engineering and Mathematics (STEM) careers.

EXTENDED BIO *- https://www.nasa.gov/feature/langley/clayton-p-turner-deputy-director-nasa-langley-research-center*

ASSOCIATE DIRECTOR
MS. CATHY H. MANGUM

Ms. Mangum began her NASA career in 1983 as a contractor for the Science Mission Directorate at NASA HQ.

Through her career, she served as Information Technology Manager for the Aeronautics Mission Directorate and Director of the Management Operations Division in the Office of Aeronautics.

After helping institutionalize the federal Chief Information Officer (CIO) role, she served as acting CIO and became Langley's CIO.

EXTENDED BIO *- https://www.nasa.gov/feature/langley/cathy-h-mangum-associate-director-nasa-langley-research-center*

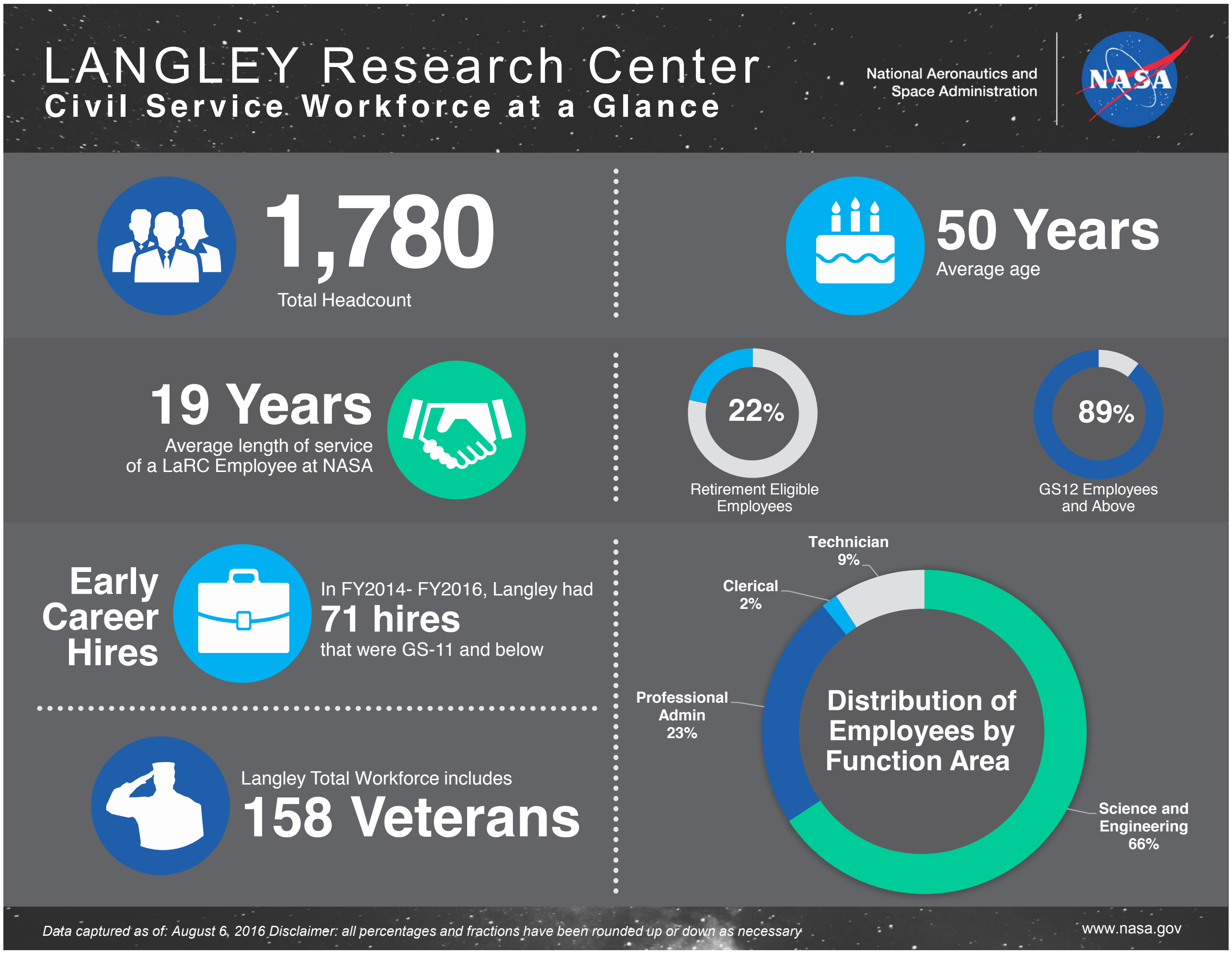


Figure 49.2 Langley Research Center Workforce at a Glance

! ADDITIONAL RESOURCES

- WWW [Langley Aeronautics]
- WWW [Langley Exploration]
- WWW [Langley Science]
- [Langley Annual Report]
- [Recent Accomplishments]
- WWW [Centennial Website]

MARSHALL SPACE FLIGHT CENTER (MSFC)

MISSION STATEMENT

On behalf of the Agency Marshall Space Flight Center provides leadership in the complex engineering of space transportation and propulsion systems, large space structures and systems, and scientific research to make human space exploration a reality. Marshall is responsible for the SLS as well as developing advanced technologies that are necessary for the human journey to Mars. Marshall also manages a number of programs and projects, including the ISS environmental control and life support system, its payload operations, and numerous other facilities and experiments; the Chandra X-ray Observatory; the Discovery and New Frontiers programs; space technology demonstration missions; and the Michoud Assembly Facility where space vehicles are manufactured and assembled.

CENTER WEBSITE *- http://www.nasa.gov/centers/marshall/home/index.html*
YEAR IN REVIEW VIDEO *- https://www.youtube.com/watch?v=gUFFkrnE1pY*

IMAGE 50.1

MARSHALL SPACE FLIGHT CENTER CORE FUNCTIONS

PROPULSION SYSTEM DEVELOPMENT
Advancing launch and in-space propulsion systems for low Earth orbit, cis-lunar orbit, and beyond.

LARGE SPACE STRUCTURE DEVELOPMENT
Analyzing, developing, and testing advanced large-scale, complex structures for deep space exploration.

SPACE SYSTEMS
Advancing environmental control and life support systems, developing payloads, and characterizing space environments to live and work in space.

SCIENTIFIC RESEARCH
Developing and applying the next generation of astrophysics, heliophysics, and Earth science instruments.

ADVANCED AND LARGE-SCALE MANUFACTURING
Innovating materials and methods to minimize cost and schedule through use of advanced composite, welding, and additive manufacturing techniques.

MARSHALL SPACE FLIGHT CENTER DESCRIPTION

Located among dozens of federal agencies on Redstone Arsenal in Huntsville, AL, adjacent to Cummings Research Park, the second-largest research park in the nation.

Marshall Space Flight Center delivers highly skilled, cross-cutting engineering and support services to a broad spectrum of human exploration, science, and technology development missions. MSFC also manages the Michoud Assembly Facility, where the core stage of Space Launch System (SLS) and the Orion crew vehicle are being built.

MSFC is developing the SLS and other critical elements and technologies essential for the nation's human space exploration mission. Payload operations for the International Space Station (ISS) are managed at Marshall's Payload Operations and Integration Center. Marshall also enables scientific discovery through development and testing of hardware and instruments for a variety of projects in high-energy astrophysics, heliophysics, and applied Earth science.

MARSHALL SPACE FLIGHT CENTER COMPONENT FACILITIES

THE MICHOUD ASSEMBLY FACILITY

The Michoud Assembly Facility is a component facility of MSFC. Michoud, located in New Orleans, Louisiana, is one of the largest manufacturing facilities in the world and for more than 50 years has been entrusted with the unique manufacturing and assembly needs of NASA's human space exploration programs. Michoud is committed to the highest safety standards, leading technical innovation, and fostering commercial and government agency public/private partnerships that have achieved its goal of reduction in operating and program costs.

IMAGE 50.2

MARSHALL SPACE FLIGHT CENTER ORGANIZATION

Marshall Space Flight Center is located on Redstone Arsenal. Because of its location, Marshall has synergistic relationships with various Team Redstone partners, including the Army's Aviation and Missile Command; Space and Missile Defense Command; Aviation and Missile Research, Development and Engineering Center; the Missile Defense Agency; and the Defense Intelligence Agency's Missiles and Space Intelligence Center. Collaborative efforts between MSFC and DoD partners have resulted in time and cost savings for shared interests in aerospace capabilities.

The Center organizational chart provides insight into the official roles and relationships within MSFC.

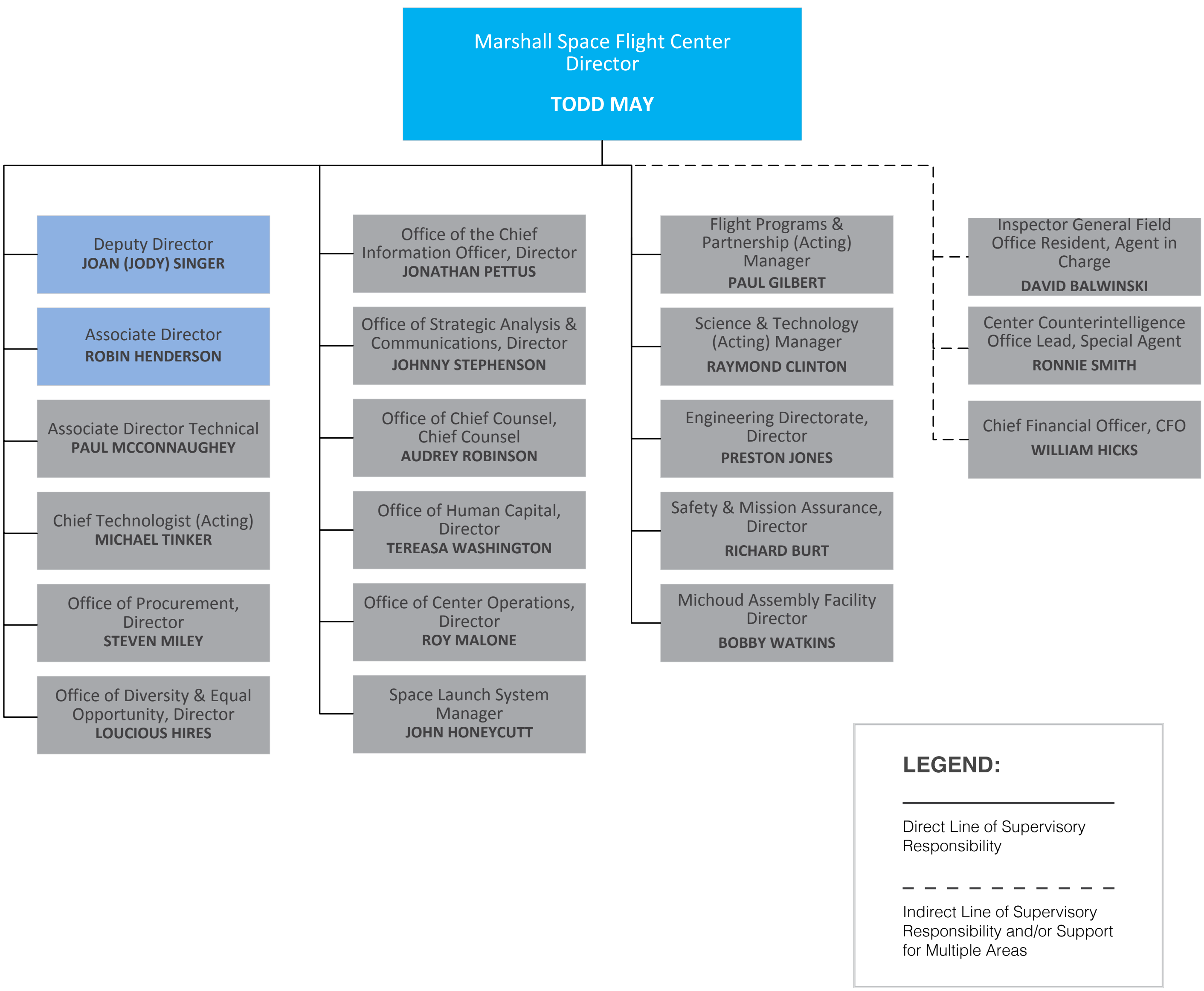


Figure 50.1 Marshall Space Flight Center (MSFC) Organization Chart

CENTER DIRECTOR
MR. TODD MAY

Todd May is Director of NASA's Marshall Space Flight Center in Huntsville, Alabama, one of NASA's largest field installations. May manages a broad spectrum of human spaceflight, science and technology development missions contributing to the nation's space program, including the Space Launch System. SLS, now under development, is the most powerful rocket ever built, able to carry astronauts in NASA's Orion spacecraft on deep space missions, including to an asteroid and ultimately to Mars.
EXTENDED BIO - *http://www.nasa.gov/sites/default/files/atoms/files/todd_may_bio_2016.pdf*

DEPUTY CENTER DIRECTOR
MS. JODY SINGER

Joan A. (Jody) Singer is Deputy Director of NASA's Marshall Space Flight Center. Named to the position in February 2016, Singer assists Marshall Director Todd May in managing the Center. Previously, Singer has held several Marshall leadership positions, including Manager of the Flight Programs and Partnerships Office, Deputy Manager of the Space Launch System Program, and Deputy Manager of the Space Shuttle Propulsion Office.
EXTENDED BIO - *http://www.nasa.gov/sites/default/files/atoms/files/jody_singer_bio_2016.pdf*

ASSOCIATE DIRECTOR
MS. ROBIN HENDERSON

Robin Henderson, Associate Director of NASA's Marshall Space Flight Center, manages and leads development of the Center's business operations, guides daily business decisions, and oversees Center operational policy and processes. In addition, she serves as a Senior Advisor in advancing the direction of the Center's future.
EXTENDED BIO - *http://www.nasa.gov/sites/default/files/atoms/files/robin_henderson_bio_2016.pdf*

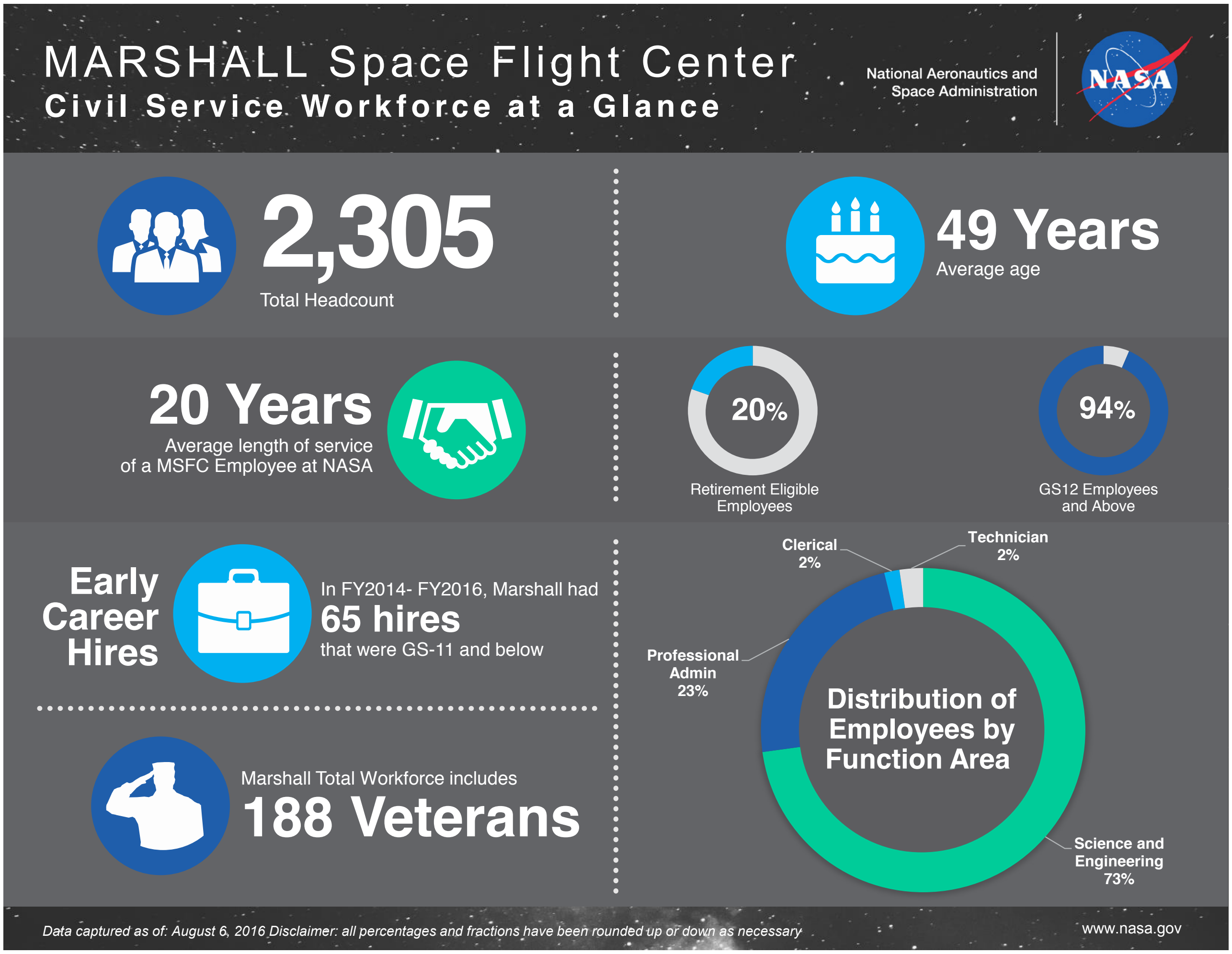


Figure 50.2 Marshall Space Flight Center Workforce at a Glance

ADDITIONAL RESOURCES

- www [SLS Overview]
- www [Marshall Missions]
- www [Marshall Capabilities]
- [ISS: Payload Operations Integration Center]
- www [Marshall Economic Impact and Community Involvement]
- [SLS Small Business]

STENNIS SPACE CENTER (SSC)

MISSION STATEMENT

On behalf of the Agency Stennis Space Center (SSC) implements NASA's mission in areas assigned by two Agency Mission Directorates. The Center manages and operates rocket propulsion test facilities and supports infrastructure for the Human Exploration and Operations Mission Directorate. SSC also serves as Federal manager and host Agency of a major government multi-agency Center.

CENTER WEBSITE - *http://www.nasa.gov/centers/stennis/home/*

IMAGE 51.1

STENNIS SPACE CENTER CORE FUNCTIONS

ROCKET PROPULSION TESTING

SSC provides propulsion test services for NASA, the Department of Defense, and commercial customers. SSC supports NASA's Space Launch System (SLS) program through testing RS-25 engines and ultimately the SLS core stage.

TECHNOLOGY

The SSC technology line of business develops, demonstrates, and deploys technology for NASA's Human Exploration and Operations Mission Directorate (HEOMD) and the Space Technology Mission Directorate (STMD) for test operations and exploration missions. SSC also supports the Office of the Chief Technologist (OCT) by transferring intellectual property to other NASA Centers, government agencies, U.S. industry, and academia.

STENNIS SPACE CENTER DESCRIPTION

Stennis Space Center (SSC) is located on the Mississippi Gulf Coast near Bay St. Louis, MS. The area of the site is approximately 13,800 acres and is surrounded by a 125,000 acre acoustical buffer zone. SSC serves as the nation's premier rocket propulsion testing facility and provides propulsion test services for NASA, the Department of Defense, and commercial customers.

SSC is a unique federal city, hosting over 40 federal, state, academic, and commercial interests, many of them engaged in technology-based initiatives. The resultant marine science technology cluster is an economic driver for the region, supporting federal, state, and commercial interests. SSC also hosts several universities such as Mississippi State University and the University of Southern Mississippi which offer a range of doctoral programs in engineering and marine science disciplines, respectively. Institutional operational costs are shared among resident agencies, making it more cost-effective for tenants to accomplish their respective missions. Stennis is also home to the NASA Shared Services Center (NSSC) that performs integrated administrative functions and transactional activities for NASA in the areas of human resources, information technology, finance, and procurement.

The Center's unique test facilities and technical expertise in the areas of chemical propulsion, cryogenic systems, and facilities engineering will play a key role in the development and certification of new propulsion systems for the Space Launch System (SLS) vehicle. Throughout FY 2016, refurbishment and modification of the B-2 Test Stand will transition to activating the stand to support future Space Launch Systems (SLS) core stage testing. Recently SSC expanded its restricted airspace to support propulsion testing activities and Department of Defense operations as well as use of unmanned aerial systems.

SSC also houses the largest concentration of operational and research oceanographers in the world. NASA and Navy interests routinely collaborate on projects focusing on the development and utilization of technology applications.

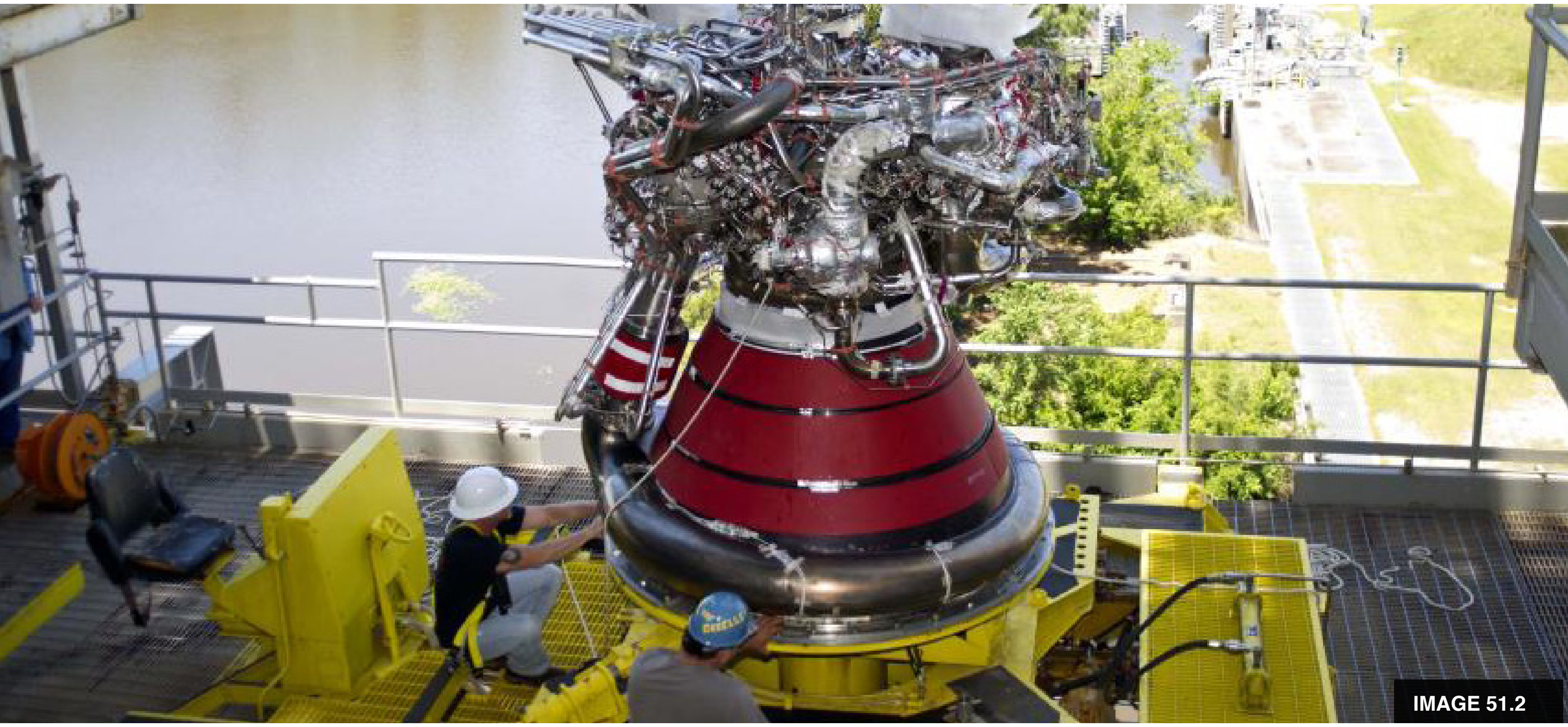


IMAGE 51.2

STENNIS SPACE CENTER ORGANIZATION

The NASA Center Director is the base commander for the multi-agency facility. The Departments of Commerce, Defense and Interior have a significant presence at SSC. In addition, multiple commercial interests maintain operations at the Center including Aerojet Rocketdyne, Lockheed Martin and Rolls Royce.

The Center organizational chart provides insight into the official roles and relationships within SSC.

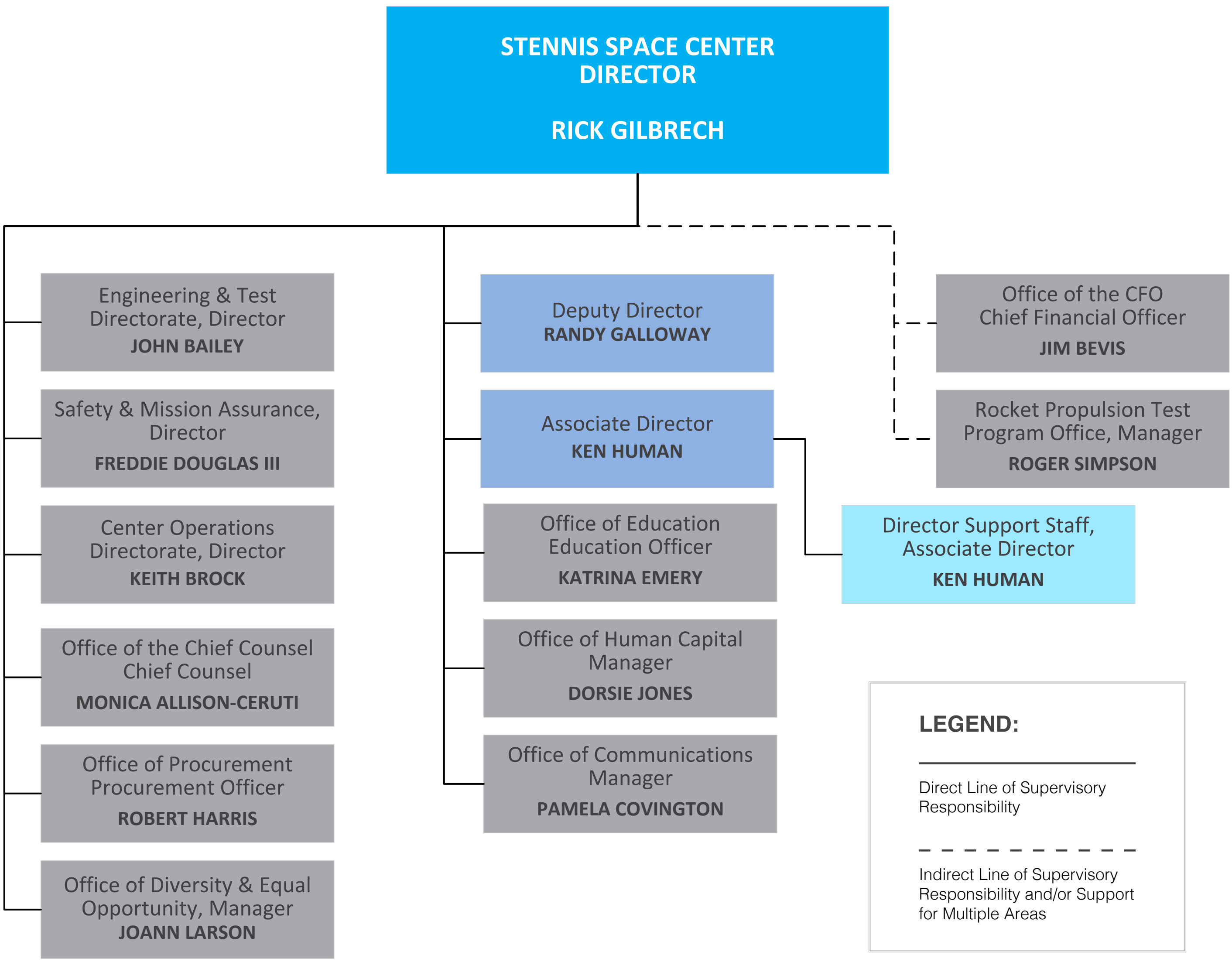


Figure 51.1 Stennis Space Center (SSC) Organization Chart

CENTER DIRECTOR
DR. RICHARD J. GILBRECH

Dr. Richard J. Gilbrech serves as Director of NASA's John C. Stennis Space Center. He is responsible for implementing NASA's mission in the area of rocket propulsion testing and developing and maintaining world-class propulsion test facilities as well as managing the multi-tenant federal facility. He was Associate Administrator for NASA's Exploration Systems Mission Directorate in 2007, leaving NASA in 2008 to work in industry. He returned to SSC in 2009 as Associate Director. Dr. Gilbrech received a B.S. from Mississippi State University and M.S. and Ph.D. degrees in Aeronautics from the California Institute of Technology. He is the recipient of numerous awards, including Distinguished and Meritorious Presidential Rank Awards.
EXTENDED BIO - *http://www.nasa.gov/centers/stennis/about/history/personalities/gilbrech.html*

DEPUTY CENTER DIRECTOR
MR. T. RANDY GALLOWAY

Randy Galloway serves as Deputy Director of NASA's John C. Stennis Space Center. He is responsible, with the Center Director, for coordinating all of NASA's rocket propulsion testing capabilities, as well as managing Stennis. Prior to accepting his current position, Galloway was Director of Stennis' Engineering and Test Directorate. He also worked on the International Space Station Program, holding several key positions. Galloway is a recipient of NASA's Exceptional Achievement Medal (2001) and the Outstanding Leadership Medal (2015). He also received Stennis Space Center's J. Harry Guin Leadership Award in 2012. Galloway received a Bachelor of Science in Mechanical Engineering from Mississippi State University.
EXTENDED BIO - *http://www.nasa.gov/centers/stennis/about/history/personalities/galloway.html*

ASSOCIATE DIRECTOR
MR. KENNETH R. HUMAN

Kenneth R. Human serves as Associate Director of NASA's John C. Stennis Space Center. He is responsible, with the Director, for coordinating all of NASA's rocket propulsion testing capabilities and Stennis' role in NASA's Applied Science programs, as well as managing Stennis. Prior to assuming his current position, Human served as Deputy Manager of the External Integration Office for the International Space Stations (ISS) Program. He began his career with NASA as an attorney in the legal office at Stennis in 1978, ultimately serving as Chief Counsel for 21 years. Human received a B.A. in English literature from George Washington University and his Juris Doctor from the University of New Hampshire School of Law. He received the NASA Exceptional Service Medal in 1998.
EXTENDED BIO - *http://www.nasa.gov/centers/stennis/about/history/personalities/ken_human.html*

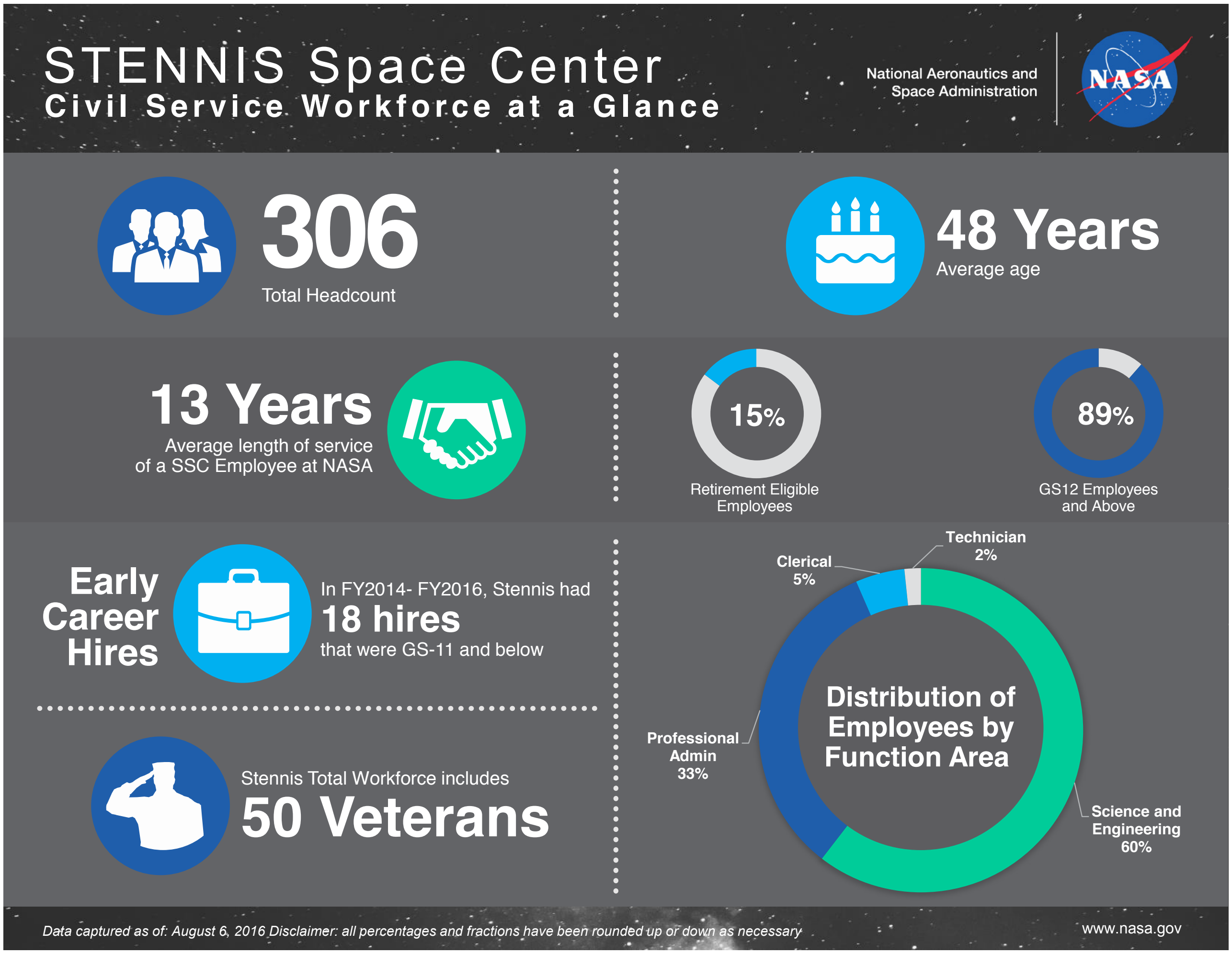


Figure 51.2 Stennis Space Center Workforce at a Glance

ADDITIONAL RESOURCES

- [SSC Education Website]
- [SSC Chief Technologist]
- [NASA Internships and Fellowships]
- [Infinity Science Center]
- [SSC Engineering and Test Directorate]

APPENDICES

APPENDIX A: GLOSSARY

Acquisition
Obtaining, or advancing the development of, the systems, research, services, construction, and supplies to fulfill the Agency's mission and other activities that advance the Agency's statutory objectives.

Appropriation Bills
A legislative motion (bill) that authorizes the government to spend money. It is a bill that sets money aside for specific spending.

Approval
Authorization by a required management official to proceed with a proposed course of action. Approvals must be documented.

Assessment
The evaluation of a program, project, or institutional initiative with respect to its accomplishments and performance in meeting requirements.

Authorization Committees
Authorization Committees execute Congressional oversight of agency programs and plans.

Authorize
To give power, permission, or authorization; to invest with authority.

Baseline Performance Review
While not a council, the Baseline Performance Review (BPR) is closely linked with the councils and is integral to council operations. The BPR is an internal assessment and reporting forum that tracks performance monthly against Agency plans.

Business Services Assessment
A series of assessments designed to establish a more efficient operating model that maintains a minimum set of capabilities and meets current and future mission needs.

Center Technology Council (CTC)
Assesses the Agency technology roadmapping and technology prioritization activities from a bottoms-up, institutional perspective, and provides these assessments to NASA Technology Executive Council. Council membership includes the Center Chief Technologist from each NASA Center (including Jet Propulsion Laboratory), and a representative from the Office of Chief Engineer, and is observed by a representative from each Mission Directorate. The Strategic Integration Office, under the NASA Office of the Chief Technologist organizes and chairs the CTC.

Cislunar Space
The region outside Earth's atmosphere and extending out to just beyond the Moon's orbit. This is a relatively stable environment and as such is an important locale for demonstrating in-space technologies and capabilities for deep space trajectories and orbits.

Communications Coordinating Council (CCC)
Serves as the Agency's senior decision-making body for strategic direction, planning, and implementation for NASA's Communications efforts. The CCC determines NASA strategic Communications direction and assesses Agency progress toward achieving NASA's Communications Strategic Implementation Plan.

Competition
An acquisition strategy whereby more than one Center or contractor is sought to bid on a service or function; the winner is selected on the basis of criteria established by the organization for which the work is to be performed. The law and NASA policy require maximum competition throughout the acquisition life cycle.

Concurrence
A documented agreement by a management official that a proposed course of action is acceptable.

Continuing Resolution
Legislation in the form of a joint resolution enacted by Congress to provide budget authority for Federal agencies and programs to continue in operation until regular appropriations acts are enacted.

Continutity of Operations (COOP)
Plans developed on the four foundations of continuity planning and program management: leadership, staff, communications/technology, and facilities to ensure the continuous performance of essential functions under all conditions.

Contracts
All types of agreements and orders for the procurement of supplies or services. Includes awards and notices of award; contracts of a fixed-price, cost, cost-plus-a-fixed-fee, or incentive type; contracts providing for the issuance of job orders, task orders, or task letters thereunder; letter contracts; and purchase orders. It also includes supplemental agreements with respect to any of the foregoing.

Cooperative Agreement
A legal instrument reflecting a relationship between the U.S. Government and a State or local government or other recipient when: 1) The principal purpose of the relationship is to transfer a thing of value to the State or local government or other recipient to carry out a public purpose of support or stimulation authorized by a law of the United States instead of acquiring (by purchase, lease, or barter) property or services for the direct benefit or use of the U.S. Government; and 2) Substantial involvement is expected between the executive agency and the State or local government or other recipient when carrying out the activity contemplated in the agreement.

Cost-Plus-Fixed-Fee Contracts
A cost-plus-fixed-fee contract is a cost-reimbursement contract that provides for payment to the contractor of a negotiated fee that is fixed at the inception of the contract. The fixed fee does not vary with actual cost, but may be adjusted as a result of changes in the work to be performed under the contract. This contract type permits contracting for efforts that might otherwise present too great a risk to contractors, but it provides the contractor only a minimum incentive to control costs.

Cross-Agency Priority (CAP) Goals
A statement of the long-term level of desired performance improvement for Government-wide goals set or revised at least every four years. These include outcome-oriented goals that cover a limited number of crosscutting policy areas and management goals addressing financial management, strategic human capital management, information technology management, procurement and acquisition management, and real property management

Education Coordinating Council (ECC)
Serves as the Agency's senior decision-making body for strategic direction and planning related to education. The ECC determines NASA strategic education direction and assesses Agency progress toward achieving NASA's educational Vision.

Executive Council (EC)
The Executive Council (EC) determines NASA's strategic direction, assesses Agency progress toward achieving the NASA Vision, and serves as the Agency's senior decisionmaking body for Agency-wide decisions. For topics dealing with Agency strategic direction and planning, the EC Chair may call a meeting of the Strategic Management Council, which acts in the "extended EC" mode. Members of both councils advise the Administrator in the Administrator's capacity as Council Chair and decision authority.

Exon-Florio Act
The Exon–Florio Act is a law that was enacted by the United States Congress in 1988 to review foreign investment within the United States. The amendment was passed into law under the Omnibus Trade and Competitiveness Act of 1988.

Export Control Program
NASA-wide system established to ensure that exports and transfers to foreign parties in international activities are consistent with the Export Administration Regulation and the International Traffic in Arms Regulation (ITAR) and NASA international cooperative activities.

Federal Employee Viewpoint Survey
The Federal Employee Viewpoint Survey (FEVS) is a tool that measures employees' perceptions of whether, and to what extent, conditions characterizing successful organizations are present in their agencies. Survey results provide valuable insight into the challenges agency leaders face in ensuring the Federal Government has an effective civilian workforce and how well they are responding.

Federally Funded Research and Development Centers (FFRDC's)
Activities that are sponsored under a broad charter by a Government agency (or agencies) for the purpose of performing, analyzing, integrating, supporting, and/or managing basic or applied research and/or development, and that receive 70 percent or more of their financial support from the Government; and - (1) A long-term relationship is contemplated; (2) Most or all of the facilities are owned or funded by the Government; and (3) The FFRDC has access to Government and supplier data, employees, and facilities beyond that common in a normal contractual relationship.

Firm-Fixed-Price Contracts
A firm-fixed-price contract provides for a price that is not subject to any adjustment on the basis of the contractor's cost experience in performing the contract. This contract type places upon the contractor maximum risk and full responsibility for all costs and resulting profit or loss. It provides maximum incentive for the contractor to control costs and perform effectively and imposes a minimum administrative burden upon the contracting parties.

Full Cost Accounting
Full cost accounting is a concept that ties all agency costs (including Civil Service personnel costs) to major activities (programs) and budgets, accounts, reports and manages programs with a full cost perspective.

Full-Time Equivalent (FTE)
Full-time equivalent employees equal the number of employees on full-time schedules plus the number of employees on part-time schedules converted to a full-time basis. The number of full-time equivalent employees in each industry is the product of the total number of employees and the ratio of average weekly hours per employee for all employees to average weekly hours per employee on full-time schedules. An industry's full-time equivalent employment will be less than the number of its employees on full- and part-time schedules, unless it has no part-time employees.

Grant
A legal instrument reflecting a relationship between the U.S. Government and a State or local government or other recipient when: 1) The principal purpose of the relationship is to transfer a thing of value to the State or local government or other recipient to carry out a public purpose of support or stimulation authorized by a law of the United States instead of acquiring (by purchase, lease, or barter) property or services for the direct benefit or use of the U. S. Government; and 2) Substantial involvement is not expected between the executive agency and the State or local government or other recipient when carrying out the activity contemplated in the agreement.

Incentive Fee Contracts
An incentive fee provision can be included in a contract to encourage the contractor, through a suitable monetary incentive, to provide the management, equipment, materials, labor, and supervision necessary for performance improvement.

Institutional Authorities
The Institutional Authority consists of those organizations not in the Programmatic Authority. As part of Institutional Authority, NASA established the Technical Authority process as a system of checks and balances to provide independent oversight of programs and projects in support of safety and mission success through the selection of specific individuals with delegated levels of authority. Individuals with these formal delegations are Technical Authorities.

International Space Exploration Coordination Group (ISECG)
The ISECG is a voluntary, non-binding international coordination mechanism through which individual agencies may exchange information regarding interests, objectives, and plans in space exploration with the goal of strengthening both individual exploration programs as well as the collective effort. Together with 13 other space agencies, NASA participates in the International Space Exploration Coordination Group (ISECG) to advance a long-range human space exploration strategy.

Inventions and Contributions Board (ICB)
ICB is run by the NASA Office of General Counsel and encourages innovation by offering incentives to NASA researchers and inventors. Authorized to approve substantial monetary awards, the Board reviews technical contributions to the Government and Nation.

Low Earth Orbit (LEO)
The first 100 to 200 miles of space. The International Space Station is in LEO and serves as a critical testbed for research, technology, and earth reliant proving ground demonstrations for the Journey to Mars.

Mission Support Council (MSC)
The Mission Support Council (MSC) serves as the Agency's senior decision-making body regarding the integrated Agency mission support portfolio, and mission support plans and implementation strategies (including facility, infrastructure, technical capabilities and associated investments). The council members are advisors to the Associate Deputy Administrator, in the capacity as the MSC Chair and decision authority. The MSC determines and assesses mission support requirements to enable the successful accomplishment of the Agency's Mission.

Multilateral Coordination Board (MCB)
The International Space Station Multilateral Coordination Board (MCB) is the highest-level cooperative body in the International Space Station program. It was set up under the Memoranda of Understanding for the ISS, originally signed in 1998.

NASA Advisory Council (NAC)
The NASA Advisory Council provides the NASA Administrator with counsel and advice on programs and issues of importance to the Agency. The council consists of six committees, Aeronautics, Audit and Finance, Exploration, Human Capital, Sciences, and Space Operations. Each committee conducts fact-finding sessions throughout the year in an effort to gain broad understanding of current NASA issues and future mission implementation plans. The committees then bring this information to the full Council in order that specific recommendations may be prepared.

NASA Governance and Strategic Management Handbook
Sets forth NASA's governance framework which are the principles and structures through which the Agency manages missions, roles, and responsibilities; and describes NASA's Strategic Management System, the processes by which the Agency manages strategy and its implementation through planning, performance, and results.

NASA Policy Directive (NPD)
This directive sets forth NASA's governance framework — principles and structures through which the Agency manages mission, roles, and responsibilities — and describes NASA's Strategic Management System — processes by which the Agency manages strategy and its implementation through planning, performance, and results.

NASA Procedural Requirements (NPR)
The NASA Procedural Requirements (NPR) establishes the responsibilities and procedures for NASA directives and processes.

NASA Strategic Management System
Composed of a set of continuous processes that, as a whole, allow NASA to assess the allocation of its resources in achieving its planned performance goals. The system's emphasis on program performance and results uses the findings from internal and external reviews and evaluations as input to successive planning and programming processes.

NASA Technology Executive Council (NTEC)
Performs Agency-level technology integration, coordination and strategic planning. Council membership includes the Mission Directorate Associate Administrators (or their designees), and the NASA Chief Engineer (or designee). The NASA Chief Technologist chairs the NTEC.

National Aeronautics and Space Act
Signed by President Dwight Eisenhower on July 29, 1958, the National Aeronautics and Space Act of 1958 "provided for research into the problems of flight within and outside the earth's atmosphere" and established the National Aeronautics and Space Administration (NASA).

National Space Policy of the United States of America
The National Space Policy expresses the President's direction for the Nation's space activities. The policy articulates the President's commitment to reinvigorating U.S. leadership in space for the purposes of maintaining space as a stable and productive environment for the peaceful use of all nations.

Next Generation Air Transportation System (NextGen)
The new Federal Aviation Administration (FAA) suite of technologies and procedures that is transforming the air traffic control system from a radar-based system (radio comunications) to a satelite-based one.

Non-Reimbursable Space Act Agreement
Non-reimbursable Space Act Agreements involve NASA and one or more Agreement Partners in a mutually beneficial activity that furthers the Agency's missions, wherein each party bears the cost of its participation, and there is no exchange of funds between the parties.

North American Industry Classification System (NAICS) Codes
The North American Industry Classification System (NAICS) classifies business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. economy. The NAICS industry codes define establishments based on the activities in which they are primarily engaged.

Omnibus Appropriations Bills
An omnibus spending bill is a type of bill in the United States that packages many of the smaller regular appropriations bills into one larger single bill that could be passed with only one vote in each house.

Oversight
To actively monitor the implementation of assigned actions, policy, and procedures. Headquarters officials with an oversight role have the responsibility to establish and track performance parameters to ensure assignees are properly implementing their actions, policies, and procedures.

Passback
Office of Management and Budget (OMB) notification to agencies of budget, management, and policy decisions following its analysis and review of all agency budget submissions. Passback data is pre-decisional in nature and is not widely distributed or released.

Performance Goal
A target level of performance at a specified time or period expressed as a tangible, measurable outcome against which actual achievement can be compared, including a goal expressed as a quantitative standard, value, or rate. A performance goal is comprised of annual performance indicators with targets and timeframes.

Performance Indicator
Indicators, statistics, or metrics used to gauge program performance, in support of performance goals. These are generally established on an annual basis to correspond with the budget process.

President's Budget Request (PBR)
The annual proposed Government budget, as developed by the Executive Branch and submitted to Congress for consideration. The PBR includes department and agency requirements that have been integrated to form a cohesive Federal budget plan. NASA submits PBR budget data through MAX A-11 and supports the PBR release with a detailed agency budget plan and justification.

Procurement
The acquiring by contract with appropriated funds of supplies or services (including construction) by and for the use of the Federal Government through purchase or lease, whether the supplies or services are already in existence or must be created, developed, demonstrated, and evaluated.

Program
A strategic investment by a Mission Directorate or Mission Support Office that has a defined technical approach, requirements, funding level, and a management structure that initiates and directs one or more projects. A program defines a strategic direction that the Agency has identified as critical.

Program / Project Life Cycle
NASA manages programs and projects to life cycles that are divided into defined phases that correspond to specific activities and increasing levels of expected maturity of information and products. A program or project moves through the life cycle phases as it progresses from concept to operations, and ultimately to decommissioning. Programs and projects are periodically evaluated at specific points to gain formal approval to progress through their life cycle.

Program Management Council (PMC)
The Program Management Council (PMC) serves as the Agency's senior decisionmaking body regarding the integrated Agency mission portfolio. The PMC baselines and assesses performance of NASA projects, programs, Mission Directorate portfolios, and the integrated Agency portfolio to ensure achievement of NASA strategic goals. The council members are advisors to the Associate Administrator in the capacity as the PMC Chair and decision authority.

Project
A specific investment having defined goals, objectives, requirements, life-cycle cost, a beginning, and an end. A project yields new or revised products or services that directly address NASA's strategic goals. They may be performed wholly in-house, by Government, industry, academic partnerships, or through contracts with private industry.

Reimbursable Funding
Funds transferred among agencies as payments for services provided by one agency to another.

Security Operations Center (SOC)
NASA's nerve center for detection and monitoring of security incidents for the Agency, providing continuous, uninterrupted event detection, situational awareness, incident management and tracking. The SOC maintains a sound and secure information assurance posture for more than 100,000 (including telephones) devices and users across NASA.

Senior Management Council (SMC)
In addition to the governing councils, the Administrator may convene NASA senior leadership to advise on key issues and strategy through the Senior Management Council (SMC) and other non-governing bodies that may be established under NPD 1000.3.

Space Act
See National Aeronautics and Space Act

Space Act Agreement
A binding agreement entered into under the "other transaction" authority in the Space Act between NASA and another party ("Agreement Partner"). Space Act Agreements can be Reimbursable (NASA's costs are reimbursed for its unique goods, services, or facilities), Nonreimbursable (there is no exchange of funds), or Funded (appropriated funds are transferred to a domestic Agreement Partner to accomplish an Agency mission). Properly obligated budget authority remains obligated after the appropriation expires for liquidating the ordering agency's obligation as the performing agency completes the work (i.e., it does not have to be deobligated before the appropriation expires, like Economy Act obligations). However, as with other contractual obligations, once the agency liquidates the obligation, any remaining balances are subject to the original purpose and time limitations and are not available for new obligation after the account has expired.

Stakeholder
An individual or organization that is materially affected by the outcome of a decision or deliverable but is outside the organization doing the work or making the decision.

Strategic Management
A series of integrated activities that enable the Agency to establish and execute strategy, make decisions, allocate resources, formulate and implement programs and projects, and measure their performance.

Strategic Objective
Strategic objectives reflect the outcome or management impact the Agency is trying to achieve. Each objective is tracked through a suite of performance goals and annual performance indicators. Strategic objectives and performance goals should facilitate prioritization and assessment for planning, management, reporting, and evaluation purposes. Strategic objectives are used to help decide which indicators are most valuable to provide leading and lagging information, monitor Agency operations, show how employees contribute to the organization's mission, determine program evaluations needed, communicate Agency progress, and consider the impact of external factors on the agency's progress. The set of all Agency strategic objectives together should be comprehensive of all agency activity. Objectives are usually outcome-oriented as it relates to the Agency's mission; however, management and other objectives may be established to communicate the breadth of Agency efforts.

Strategic Plan
The Strategic Plan presents the long-term objectives the Agency hopes to accomplish, set at the beginning of each new term of an Administration. It describes general and longer-term goals the Agency aims to achieve, what actions the Agency will take to realize those goals and how the agency will deal with the challenges likely to be barriers to achieving the desired result. An Agency's Strategic Plan should provide the context for decisions about performance goals, priorities, and budget planning, and 29 Governance and Strategic Management Handbook should provide the framework for the detail provided in Agency annual plans and reports.

Suborbital
A spaceflight or mission having or following a trajectory of less than one orbit.

Technical Authorities
The individuals within the technical authority process who are funded independent of a program or project and who have formally delegated Technical Authority traceable to the Administrator. The three organizations who have Technical Authorities are Engineering, Safety and Mission Assurance, and Health and Medical.

Technical Capabilities Assessment Team (TCAT)
A team chartered to establish a more efficient operating model that maintains critical capabilities and meets current and future mission needs. TCAT is developing a method to strategically address the technical capabilities required to support Agency goals and enable decision makers to make informed decisions on investing/divesting strategically within the budget while strengthening innovation in critical areas needed to advance our mission.

Technology Roadmaps
A set of 14 Technology Roadmaps that guide the development of space technologies. The 2015 NASA Technology Roadmaps expand and update the original 2012 roadmaps, providing extensive details about anticipated NASA mission capabilities and associated technology development needs.

Technology Transfer
Share the Agency's technology with industry, academia and other government agencies, making it simpler and faster for end users to acess the benefits of the Nation's investment in aerospace research.

Work-Year Equivalent (WYE)
Contract hours computed by dividing the total hours compensated (includes regular hours, leave, compensatory time used, and overtime, but excluding leave without pay) by 2,087 hours.

APPENDIX B: ACRONYMS

AAAS - American Association for the Advancement of Science
AAVP - Advanced Air Vehicles Program
AC - Advanced Composites
ACTE - Adaptive Compliant Trailing Edge
ADR - Alternative Dispute Resolution
AES - Advanced Exploration Systems
AFGE - American Federation of Government Employees
AFR - Agency Financial Report
AFRC - Armstrong Flight Research Center
AHP - Anti-Harassment Program
AI - Agency Integration
AIAA - American Institute of Aeronautics and Astronautics
AOSP - Airspace Operations and Safety Program
APAC - Agency Programmatic Analysis Capability
APL - Applied Physics Laboratory
APP - Annual Performance Plan
APR - Annual Performance Report
ARC - Ames Research Center
ARCD - Aerospace Research and Career Development
ARMD - NASA's Aeronautics Research Mission Directorate
ASI - Italian Space Agency
ASM - Acquisition Strategy Meetings
ATD - Airspace Technology Demonstration
ATM - Air Traffic Management
ATOL - Air Traffic Operations Laboratory
BIS - The Commerce Department's Bureau of Industry and Security
BSA - Business Services Assessment
CAEP - Committee on Aviation Environmental Protection
CAP Goals - Cross-Agency Priority Goals
CAS - Convergent Aeronautics Solutions
CAST - Commercial Aviation Safety Team
CCC - Communications Coordinating Council
CDM - Continuous Diagnostics and Mitigation
CECR - Construction and Environmental Compliance and Restoration
CERTAIN - City Environment For Range Testing of Autonomous Integrate Navigation

APPENDIX B: ACRONYMS

CFD - Computational Fluid Dynamics
CHS - Crew Health and Safety
CI - Counterintelligence
CITC - Consolidated Information Technology Center
CJS - Commerce, Justice, Science, and Related Agencies
CKO - Chief Knowledge Office
CoF - Construction of Facilities
COLTS - Combined Loads Test System
COMSEC - Communications Security
COOP - Continuity of Operations
CoSTEM - Committee on STEM Education
CP&G - Capital Planning & Governance
CR - Continuing Resolution
CSOC - Common System Operations Costs
CT - Counterterrorism
CTC - Center Technology Council
D&I - Diversity & Inclusion
DAA - Document Availability Authorization
DATR - Dryden Aeronautical Test Range
DHS - Department of Homeland Security
DLR - German Space Agency
DoD - Department of Defense
DoE - Department of Energy
DOF - Degrees of Freedom
DOL - Department of Labor
DoS - Department of State
DSCOVR - Deep Space Climate Observer
DSN - Deep Space Network
DSS - Deep Space Station
EAR - Export Administration Regulations
EB-PRO - Enterprise Border Protection
EC - Executive Council
ECC - Education Coordinating Council
ECR - Environmental Compliance and Restoration
EEO - Equal Employment Opportunity

EEOC - U.S. Equal Employment Opportunity Commission
EIB-NAC - Enterprise Internal Border and Network Access Control
EO - Executive Order
EPA - Environmental Protection Agency
EPACS - Electronic Physical Access Control System
EPD - Educator Professional Development
EPSCoR - Experimental Program to Stimulate Competitive Research
ER - Employee Relations
ES&I - Enterprise Service I Integration
ESA - European Space Agency
ESD - Exploration Systems Development
EUMETSAT - European Organisation for the Exploitation of Meteorological Satellites
EUS - Exploration Upper Stage
EVI - Earth Venture Instrument
EVM - Earth Venture Mission
EVS - Earth Venture Suborbital
FAA - Federal Aviation Administration
FAR - Federal Acquisition Regulations
FC-STEM - Federal Coordination in STEM Education Task Force
FDA - Food and Drug Administration
FEVS - Federal Employee Viewpoint Survey
FFRDC - Federally Funded Research and Development Centers
FLL - Flight Loads Laboratory
FLRA - Federal Labor Relations Authority
FNAM - Foreign National Access Management
FOC - Full Operational Capability
FOIA - Freedom of Information Act
FTE - Full-Time Equivalent
FY - Fiscal Year
GFZ - German Research Centre for Geosciences
GOES - Geostationary Operational Environmental Satellite
GPM - Global Precipitation Measurement
GPSP - Global Positioning System-Payload
GRACE-FO - Gravity Recovery and Climate Experiment Follow-On
GRC - Glenn Research Center

APPENDIX B: ACRONYMS

GS - General Schedule
GSFC - Goddard Space Flight Center
HBCU - Historically Black Colleges and Universities
HEOMD - Human Exploration and Operations Mission Directorate
HHS - Department of Health and Human Services
HMTA - Health and Medical Technical Authority
HOA - Heads of Agency
HR - Human Resources
HRP - Human Research Program
HSFO - Human Space Flight Operations
HST - Hubble Space Telescope
HTT - High Temperature Tunnel
HUNCH - High Schools United with NASA to Create Hardware
IASP - Integrated Aviation Systems Program
ICAM - Identity, Credential, and Access Management
ICESat-2 - The Ice, Cloud, and Land Elevation Satellite-2
ICPS - Interim Cryogenic Propulsion System
IDA - International Docking Adapter
IFAR - International Forum for Aviation Research
IFPTE - International Federation of Professional and Technical Engineers
ISAAC - Integrated Structural Assembly of Advanced Composites
ISECG - International Space Exploration Coordination Group
ISIM - Integrated Science Instrument Module
ISRO - Indian Space Research Organisation
ISS - International Space Station
IT - Information Technology
ITAR - International Traffic in Arms Regulations
ITP - Insider Threat Program
ITSD - Information Technology and Security Division
IV&V - Independent Verification and Validation
IWG - Interagency Working Group
JASD - Joint Agency Satellite Division
JAXA - Japan Aerospace Exploration Agency
JPL - Jet Propulsion Laboratory
JSC - Johnson Space Center

JWST - James Webb Space Telescope
KSC - Kennedy Space Center
LAL - Langley Aerothermodynamics Laboratory
LANDIR - Landing and Impact Research Facility
LaRC - Langley Research Center
LASF - Launch Abort System Facility
LBFD - Low Boom Flight Demonstrator
LCC - Launch Control Center
LDCM - Landsat Data Continuity Mission
LEED - Leadership in Energy and Environmental Design
LEO - Low Earth Orbit
LMF - Labor Management Forum
LRA - Laser Retro-Reflector Assembly
LSP - Launch Services Program
MCB - Multilateral Coordination Board
MCC - Mission Control Center
MCMC - Mars Climate Modeling Center
MDAO - Multi-Disciplinary Analysis and Optimization
MDL - Microdevices Laboratory
MDM - Mobile Device Management
MOPS - Minimum Operational Performance Standards
MOU - Memorandum of Understanding
MPPF - Multi-Payload Processing Facility
MSC - Mission Support Council
MSFC - Marshall Space Flight Center
MSI - Minority Serving Institutions
MUREP - Minority University Research and Education Project
NAI - NASA's Astrobiology Institute
NAICS - North American Industry Classification System
NARI - NASA Aeronautics Research Institute
NAS - National Airspace System
NBL - Neutral Buoyancy Laboratory
NEO - Near-Earth Objects
NESC - NASA Engineering and Safety Centers
NFS - NASA FAR Supplement

APPENDIX B: ACRONYMS

NIFS - NASA Internships, Fellowships, and Scholarships
NISAR - NASA-ISRO Synthetic Aperture Radar
NIST - Department of Commerce's National Institute of Standard and Technology
NITTF - National Insider Threat Task Force
NMO - NASA Management Office
NNI - National Nanotechnology Initiative
NNMI - National Network for Manufacturing Innovation
NOAA - National Oceanic and Atmospheric Administration
NPD - NASA Policy Directive
NPR - NASA Procedural Requirements
NPSTA - NASA Protective Services Training Academy
NSC - National Security Council
NSF - National Science Foundation
NSSC - NASA Shared Services Center
NTEC - NASA Technology Executive Council
NTF - National Transonic Facility
OHCM - Office of Human Capital Management
OIIR - NASA Office of International and Interagency Relations
OMB - White House Office of Management and Budget
ONR - Office of Naval Research
OP3 - Open Platform Partnership Program
OPF - Orbiter Processing Facility
OPM - Office of Personnel Management
OPR - Overall Pressure Ration
OSA - Organizational Safety Assessment
OSDBU - Office of Small and Disadvantaged Business Utilization
OSTP - White House Office of Science and Technology Policy
OTA - Other Transactions Authority
OTE - Optical Telescope Element
OTIS - Optical Telescope Element and Integrated Science
PACE - Plankton, Aerosols, Clouds, and Ocean Ecosystem
PBS - Plum Brook Station
PDCO - Planetary Defense Coordination Office
PDI - Pre-Decisional Involvement
PDR - Preliminary Design Review
PHO - Potentially Hazardous Objects

APPENDIX B: ACRONYMS

PMC - Program Management Council
PPBE - Planning, Programming, Budgeting, and Execution
PPD - Presidential Policy Directive
PSM - Procurement Strategy Meeting
QuAIL - Quantum Artificial Intelligence Laboratory
R&D - Research & Development
R&T - Research & Technology
RAIF - Research Aircraft Integration Facility
RCM - RADARSAT Constellation Mission
RPT - Rocket Propulsion Test
RTCA - Radio Technical Commission for Aeronautics
RTF - Reduce the Footprint
SAA - Space Act Agreement
SAP - Special Access Programs
SAR - Synthetic Aperture Radar
SATCOM - Satellite Communications
SBIR - Small Business Innovative Research
SC - Safety Culture
SCaN - Space Communications and Navigation
SE - STEM Engagement
SEAP - STEM Education and Accountability Program
SEL - Sound Exposure Level
SFCO - Space Flight Crew Operations
SHIVER - Structural Heat Intercept, Insulation and Vibration Evaluation Rig
SIP (ARMD) - Strategic Implementation Plan
SIP (NASA Interaction with Academia and Industry) - Strategy Implementation Planning
SLF - Shuttle Landing Facility
SLS - Space Launch System
SMA - Safety and Mission Assurance
SMAP - Soil Moisture Active Passive
SMC - Senior Management Council
SME - Subject Matter Expert
SMEX - Small Explorer
SOC - Security Operations Center
SOFIA - Stratospheric Observatory for Infrared Astronomy
Space Grant - National Space Grant College and Fellowship Program

SPP - Solar Probe Plus
SSC - Stennis Space Center
SSERVI - Solar System Exploration Research Virtual Institute
SSFL - Santa Susana Field Laboratory
SSMS - Safety, Security, and Mission Services
STEM - Science, Technology, Engineering, and Mathematics
STIP - Strategic Technology Investment Plan
STS - Space Transportation System
STTR - Small Business Technology Transfer
SVMF - Spaceflight Vehicle Mockup Facility
SWOT - Surface Water Ocean Topography
SWP - Strategic Workforce Planning
SWPC - Space Weather Prediction Center
T&I - Technology & Innovation
TACP - Transformative Aeronautics Program
TBW - Truss Braced Wing
TCAT - Technical Capabilities Assessment Team
TCL - Technology Capability Level
TDRS - Tracking and Data Relay Satellite
TDT - Transonic Dynamics Tunnel
TRI - Translational Research Institute
TTT - Transformational Tools and Technologies
UAE - United Arab Emirates
UAS - Unmanned Aircraft Systems
UIC - University Innovation and Challenges
UNCOPUOS - United Nations Committee on the Peaceful Uses of Outer Space
USDA - US Department of Agriculture
USGS - U.S. Geological Survey
UTM - UAS Traffic Management
VAB - Vehicle Assembly Building
VLOS - Visual Line-of Sight
VST - Vertical Spin Tunnel
VTOL - Vertical Takeoff and Landing
WFIRST - Wide Field Infrared Survey Telescope
WSTF - White Sands Test Facility
WYE - Work-Year Equivalent

APPENDIX C: PHOTOS

APPENDIX C: PHOTOS

APPENDIX C: PHOTOS

APPENDIX C: PHOTOS

APPENDIX C: PHOTOS

APPENDIX C: PHOTOS

APPENDIX C: PHOTOS