NASA

National Aeronautics and Space Administration

Office of Inspector General

Office of Audits

NASA's Efforts to "Rightsize" its Workforce, Facilities, and Other Supporting Assets

March 21, 2017

Report No. IG-17-015

Office of Inspector General

To report, fraud, waste, abuse, or mismanagement, contact the NASA OIG Hotline at 800-424-9183 or 800-535-8134 (TDD) or visit https://oig.nasa.gov/hotline.html. You can also write to NASA Inspector General, P.O. Box 23089, L'Enfant Plaza Station, Washington, D.C. 20026. The identity of each writer and caller can be kept confidential, upon request, to the extent permitted by law.

To suggest ideas for or to request future audits contact the Assistant Inspector General for Audits at https://oig.nasa.gov/aboutAll.html.

NASA Office of Inspector General
Office of Audits

RESULTS IN BRIEF

NASA's Efforts to "Rightsize" its Workforce, Facilities, and Other Supporting Assets

March 21, 2017 IG-17-015 (A-16-004-00)

WHY WE PERFORMED THIS AUDIT

To accomplish its diverse scientific and space exploration missions, NASA relies on specialized facilities and infrastructure, unique equipment and tools, and a highly skilled civil servant and contractor workforce. These assets, collectively known as technical capabilities, are spread across NASA's 10 Centers and include more than 5,000 buildings and other structures, 17,000 civil servants, and tens of thousands of contractors. Over the years, striking the right balance among these various assets has been a top management challenge, with the Agency making a number of mostly unsuccessful attempts at "rightsizing" its technical capabilities.

In June 2012, NASA established the Technical Capabilities Assessment Team (TCAT) to identify and assess Agency technical capabilities and make recommendations for investing in, consolidating, or eliminating capabilities based on mission requirements. To institutionalize capability management into its annual planning and budgeting processes, NASA replaced TCAT with the Capability Leadership Model (CLM) in 2015. CLM is designed to advance NASA's technical capabilities to meet long-term missions, optimize deployment of capabilities across its major facilities, and transition capabilities no longer needed.

In this audit, we assessed NASA's ongoing efforts to strategically manage its technical capabilities to ensure the Agency is prepared for current and future missions. Our work included reviewing Agency guidance, analyzing selected technical capability assessments, comparing the TCAT and CLM processes to best practices drawn from successful rightsizing initiatives, and interviewing Agency officials.

WHAT WE FOUND

Through the TCAT and CLM processes, NASA has established a framework that should improve the Agency's ability to manage its technical capabilities and help make the difficult decisions regarding infrastructure and personnel required to optimally position itself for current and future missions. However, after more than 4 years, the Agency has yet to make many concrete decisions about its technical capabilities – for example, to consolidate or dispose of assets. Rather, most decisions have been iterative steps on the path to making actual determinations about technical capabilities, leaving us concerned that the Agency's efforts have been slow to produce meaningful results.

Moreover, NASA's assessments of its capabilities did not consistently include information needed to make informed decisions, including mission needs or facility usage data, analyses to determine gaps or overlaps, or recommendations to achieve cost savings. In addition, NASA did not incorporate in its process the best practices we identified from other successful rightsizing efforts, including following standardized guidance, incorporating independent analysis and cost-benefit rationales, and setting firm timeframes for completing actions. Finally, NASA continues to face the long-standing challenges of its federated governance model, uncertainty about its direction and future missions, political influence, and the lack of institutionalized processes that have hindered past Agency efforts to strategically align its technical capabilities.

We believe NASA must continue to press forward with CLM and that Agency leaders should work to further institutionalize the process, continue their efforts to promote the process both inside and outside the Agency, and take steps to ensure best practices are incorporated in future assessments. Ultimately, Agency leaders must be willing to make difficult decisions to invest, divest, or consolidate unneeded infrastructure; effectively communicate those decisions to stakeholders; and withstand the inevitable pressures from Federal, state, and local officials. Failure to do so increases the risk the Agency will continue to spend valuable resources on unneeded technical capabilities and be unable to deliver the technical capabilities required for future missions.

What We Recommended

To ensure NASA's efforts to evaluate technical capabilities are institutionalized and sustained over time, we recommended the Associate Administrator (1) create standardized guidance for performing annual capability assessments; (2) evaluate CLM assessments and teams to better ensure independence; (3) develop and institute training, communications, or other measures to ensure capability assessments are complete, thorough, and include expected goals and results; and (4) revise the CLM decision process to include implementation timeframes for dispositioning agreed upon actions.

NASA concurred with and described planned actions to address our recommendations. We consider the actions responsive and will close the recommendations upon verification of their completion.

For more information on the NASA Office of Inspector General and to view this and other reports visit http://oig.nasa.gov/.

TABLE OF CONTENTS

Acronyms

APMC	Agency Program Management Council
BRAC	Base Realignment and Closure
CLM	Capability Leadership Model
GAO	Government Accountability Office
JPL	Jet Propulsion Laboratory
MSC	Mission Support Council
OIG	Office of Inspector General
TCAT	Technical Capabilities Assessment Team

INTRODUCTION

To accomplish its diverse scientific and space exploration missions, NASA relies on specialized facilities and infrastructure, unique equipment and tools, and a highly skilled civil servant and contractor workforce. Managing these human and infrastructure-related assets – or "technical capabilities" – to ensure it has the right combination of facilities, equipment, and personnel is one of the Agency's top management challenges and an issue with which it has struggled over the years. For example, in February 2013 we reported NASA had a large number of underutilized and unneeded facilities and that previous attempts at reducing or realigning Agency infrastructure faced resistance from inside and outside the Agency and had been largely unsuccessful.[1]

On several occasions, including most recently as part of the 2010 NASA Authorization Act, Congress has instructed the Agency to undertake steps to "rightsize" its technical capabilities.[2] NASA's latest rightsizing efforts began in June 2012, when it established the Technical Capabilities Assessment Team (TCAT). The goal of TCAT was to identify and assess the technical capabilities the Agency needs to meet current and future missions and make recommendations regarding investing in, consolidating, or eliminating unneeded capabilities. In 2015, following the TCAT's assessment of the Agency's technical capabilities, NASA replaced TCAT with the Capability Leadership Model (CLM). Through CLM, NASA hopes to advance its technical capabilities to meet long-term mission needs, optimize deployment of capabilities across Centers, and transition capabilities that are no longer needed.

For this review we assessed NASA's ongoing efforts to strategically manage its technical capabilities to best prepare the Agency for its current and future missions. See Appendix A for details on our scope and methodology.

Background

NASA defines a technical capability as the equipment, facilities, infrastructure, property, support, and workforce required to accomplish a program or project. The Agency's technical capabilities are spread across 10 Centers and include more than 5,000 buildings and other structures, 17,000 civil servants, and tens of thousands of contractors.[3]

---

[1] NASA Office of Inspector General, "NASA's Efforts to Reduce Unneeded Infrastructure and Facilities" (IG-13-008, February 12, 2013).

[2] Pub. L. No. 111-267, "NASA Authorization Act of 2010," October 11, 2010. In this report, the term "rightsize" refers to the processes of restructuring an organization's infrastructure and workforce to align with current and future organizational goals.

[3] For ease of reference, we are grouping the Jet Propulsion Laboratory, a Federally-Funded Research and Development Center, together with the nine NASA Centers: Ames Research Center (Ames), Armstrong Flight Research Center (Armstrong), Glenn Research Center (Glenn), Goddard Space Flight Center (Goddard), Johnson Space Center (Johnson), Kennedy Space Center (Kennedy), Langley Research Center (Langley), Marshall Space Flight Center (Marshall), and Stennis Space Center (Stennis).

NASA's Technical Capabilities

As part of CLM, NASA categorized its technical capabilities into four types – discipline, system, research, and service – which it further subdivided into 32 capability areas.[4] The Agency identified 19 discipline capability areas ranging from Avionics to Flight Mechanics to Propulsion; 4 system capability areas (Autonomous Systems; Entry, Descent, and Landing; In-Situ Resource Utilization; and Rendezvous and Capture); 6 research capability areas (Aeronautics Research, Astrophysics, Earth Science, Heliophysics, Life Science, and Planetary); and 3 service capability areas (Aircraft Operations; Environments Testing; and Mission Operations). NASA derived the discipline capabilities from categories NASA's Engineering and Safety Center had previously established and defined.[5] The system capabilities encompass technologies that relate to the 19 discipline capabilities, the service capabilities support the discipline capabilities, and the research capabilities focus on the areas in which NASA conducts research. See Figure 1 for a full list of NASA's technical capabilities and Appendix B for additional information on the subset of 24 capabilities we reviewed for this report.

Figure 1: Technical Capability Areas by Capability Type

Discipline Capabilities

- Aerosciences
- Avionics
- Cryogenics[a]
- Electrical Power
- Flight Mechanics
- Guidance, Navigation, and Control
- Instruments and Sensors[b]
- Human Factors
- Life Support/Active Thermal
- Loads and Dynamics
- Materials
- Mechanical Systems
- Nondestructive Evaluation
- Passive Thermal
- Propulsion
- Software
- Space Environments
- Structures
- Systems Engineering[c]

System Capabilities

- Autonomous Systems[d]
- Entry, Descent, and Landing
- In-Situ Resource Utilization
- Rendezvous and Capture

Research Capabilities

- Astrophysics[e]
- Aeronautics Research[f]
- Earth Science
- Heliophysics[g]
- Life Sciences
- Planetary[h]

Service Capabilities

- Aircraft Operations
- Environments Testing
- Mission Operations

Source: NASA Office of Inspector General (OIG) presentation of Agency data.

[a] Cryogenics is the study of how to produce low temperatures and how materials behave at those temperatures.
[b] Instruments and Sensors include components, sensors, and instruments for measuring the spectral, spatial, and other observable properties of a remote target of interest, both passively and actively, such as through laser- and radar-based approaches.
[c] Systems Engineering is the application of a systematic, disciplined engineering approach that is quantifiable, recursive, iterative, and repeatable for the development, operation, maintenance, and disposal of systems integrated into a whole throughout the life cycle of a project or program.
[d] Autonomous Systems are the software, sensors, and other technology used to automate the operation of systems, such as spacecraft, habitat, and propellant loading, needed for future missions.
[e] Astrophysics studies the universe.
[f] Aeronautics Research generates concepts, tools, and technologies to advance future aircraft and studies the airspace in which they will fly.
[g] Heliophysics studies the sun, its atmosphere, and other planetary environments as elements of a single interconnected system.
[h] Planetary is the study of the solar system.

4 During our review, NASA was in the process of creating a new capability – Capability Portfolio Management, adding three capability areas to the systems type, and removing a capability area from the research type.

5 The Engineering and Safety Center performs independent testing, analysis, and assessments of high-risk Agency projects to ensure safety and mission success.

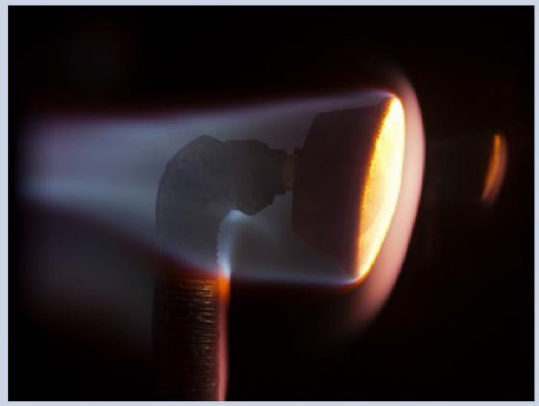
Discipline Capabilities

According to data gathered as part of NASA's capability assessments, the Agency's 19 discipline capabilities are supported by a large number of laboratories, simulators, test stands, thermal vacuum chambers, and other facilities, as well as by more than 14,800 civil servants and contractors.[6] For example, the Agency uses 16 wind tunnels to conduct research into and test solutions for various aeroscience issues, including fuel efficiency, noise, and the effect of icing on planes. Over 900 civil servants and contractors at all 10 Centers work to support this research and testing.

System Capabilities

Infrastructure that supports system-level capabilities include arc-jets, ballistic ranges, "rock yards," soil mechanics testing facilities, vacuum chambers, and wind tunnels.[7] According to NASA data, nearly 1,800 civil servant and contractor employees support these capabilities. For example, the Entry, Descent, and Landing capability encompasses systems and hardware used for slowing, approaching, connecting, and landing a vehicle on a celestial body. NASA tests these systems and hardware using arc jets and wind tunnels, while a workforce of nearly 800 civil servants and contractors located at Ames, the Jet Propulsion Laboratory (JPL), Johnson, Langley, and Marshall support this work.

Arc-Jet Testing



Source: NASA.

Research Capabilities

NASA maintains capabilities to support six research areas, including a facility at Kennedy that houses animals used in life sciences research and Distributed Active Archive Centers where data from airborne and space-borne observing systems are analyzed to advance our understanding of the Earth. More than 1,500 civil servants and contractors support these research capabilities.

---

[6] Thermal vacuum chambers are facilities in which space vehicles and related hardware and components are tested in a simulated space environment.

[7] Arc-jets are devices in which gases are heated and expanded to very high temperatures by a continuous electrical arc between two sets of electrodes and are used to develop and certify thermal protection materials and systems used during spacecraft re-entry. Ballistic ranges support research and development activities in high-velocity physics, aerodynamics, and chemistry. A rock yard is a test area that simulates general features of the Lunar and Martian surfaces consisting of slopes, grades, simulated craters, and rock strewn field conditions.

Service Capabilities

According to NASA data, over 8,000 civil servants and contractors work to support NASA's service capabilities. For example, more than 6,700 personnel and facilities at nine Centers support the Mission Operations capability, which includes the operations phase of the International Space Station, the Hubble Space Telescope, and other NASA missions.

Mission Control Center at Johnson Space Center

Source: NASA.

State of NASA's Technical Capabilities

A large portion of the infrastructure supporting NASA's technical capabilities is aging, which presents considerable risk to the Agency's overall mission as facilities degrade and become obsolete or considerably more expensive to maintain. At the same time, NASA officials acknowledge the Agency has more infrastructure than it needs to carry out current and planned missions. In addition, NASA's workforce is also aging, with a growing number of employees eligible for retirement. Compounding these issues, NASA's budget for facility maintenance has fallen far behind the Agency's needs.

Aging Facilities and Workforce

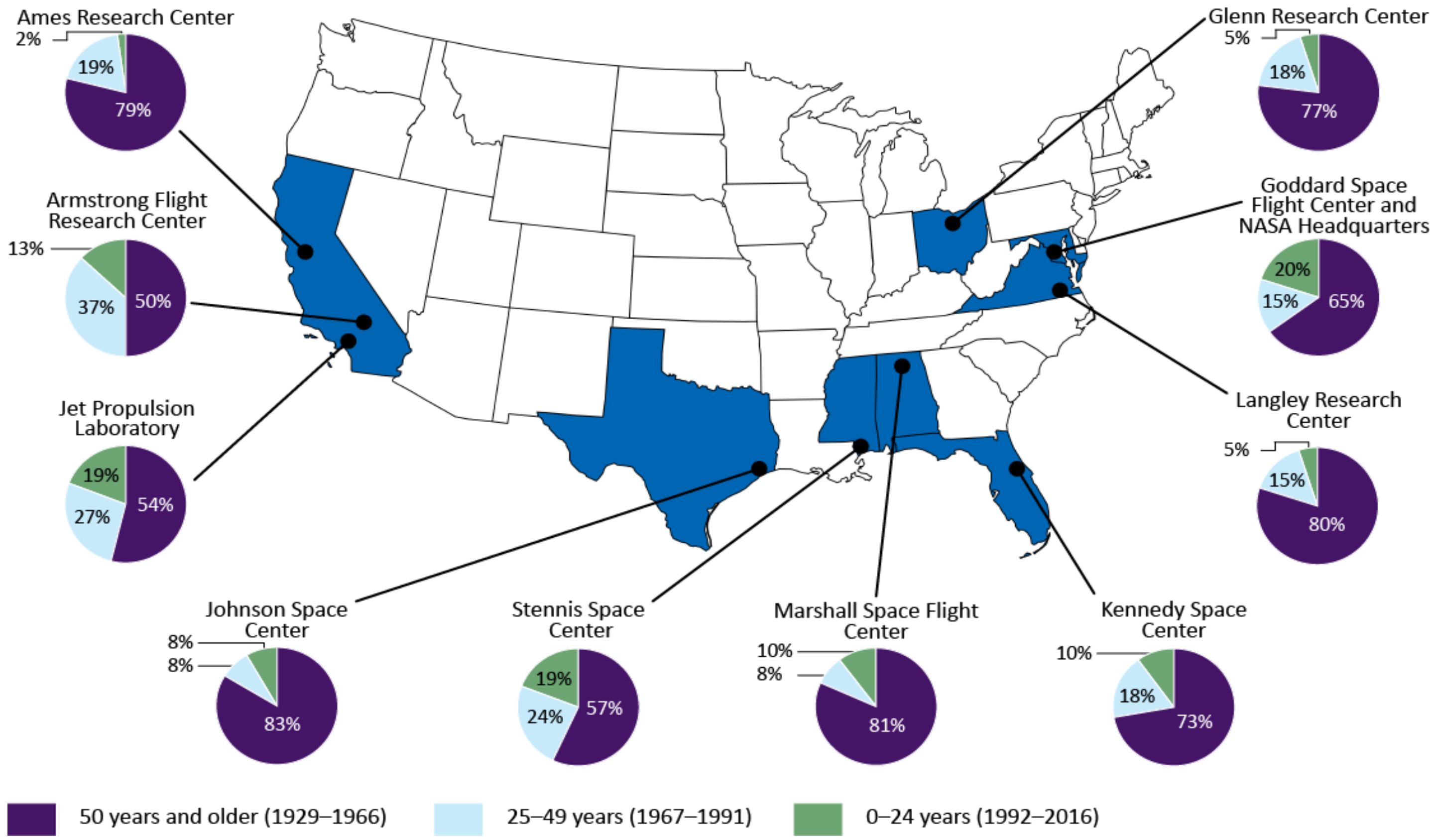
Much of NASA's infrastructure was constructed in the 1960s, and more than 70 percent of its facilities are at least 50 years old (see Figure 2). Numerous studies and reports by NASA, the NASA OIG, the Government Accountability Office (GAO), and others have focused on the Agency's aging infrastructure. For example, in 2010 the National Research Council reported that a steady and significant decrease in laboratory capabilities had adversely affected NASA's ability to make basic scientific and technical contributions to the Nation and support the Agency's goals.[8] Moreover, as of September 2016, the Agency had approximately $2.4 billion in annual deferred maintenance costs.[9]

---

[8] National Research Council, "Capabilities for the Future: An Assessment of NASA Laboratories for Basic Research," 2010.

[9] NASA's Deferred Maintenance Assessment Report, "FY 2016 NASA-Wide Standardized Deferred Maintenance Parametric Estimate," September 30, 2016. NASA defines deferred maintenance as the essential but unfunded work necessary to bring its Centers up to required facilities maintenance standards.

Figure 2: NASA's Aging Facilities

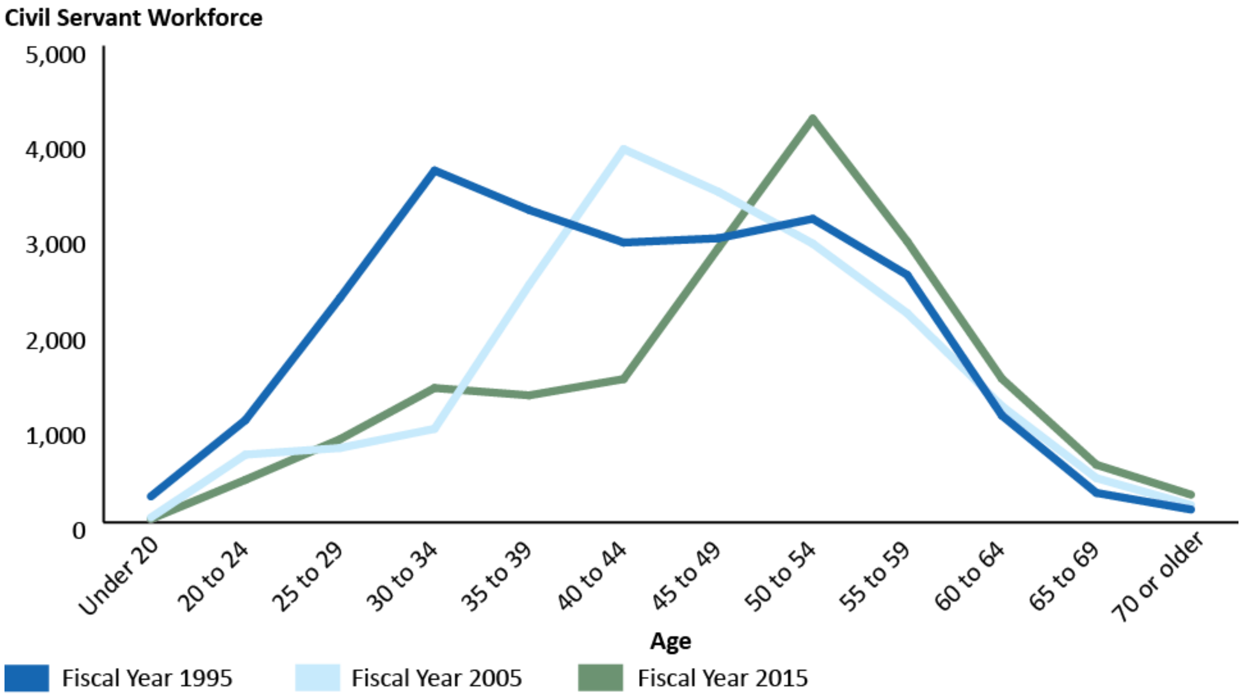


Source: NASA OIG analysis of Agency data.

Note: Percentages may be greater than 100 percent due to rounding.

NASA's workforce is also aging. Since 2000, the average age of the Agency's civil servants has increased from 44 to 49 years old. Moreover, NASA has more employees between ages 50 and 54 than in any other 5-year age group, and the majority of the workforce is 50 or older (see Figure 3). As the average age has increased, the portion of the workforce eligible to retire has also grown. As of 2014, about 45 percent of NASA's civil servant workforce is either eligible to retire or will become eligible within the next 5 years. NASA officials hope that as these retirements occur the CLM initiative will help them redistribute the workforce to the technical capabilities required for future missions.

Figure 3: NASA's Aging Workforce

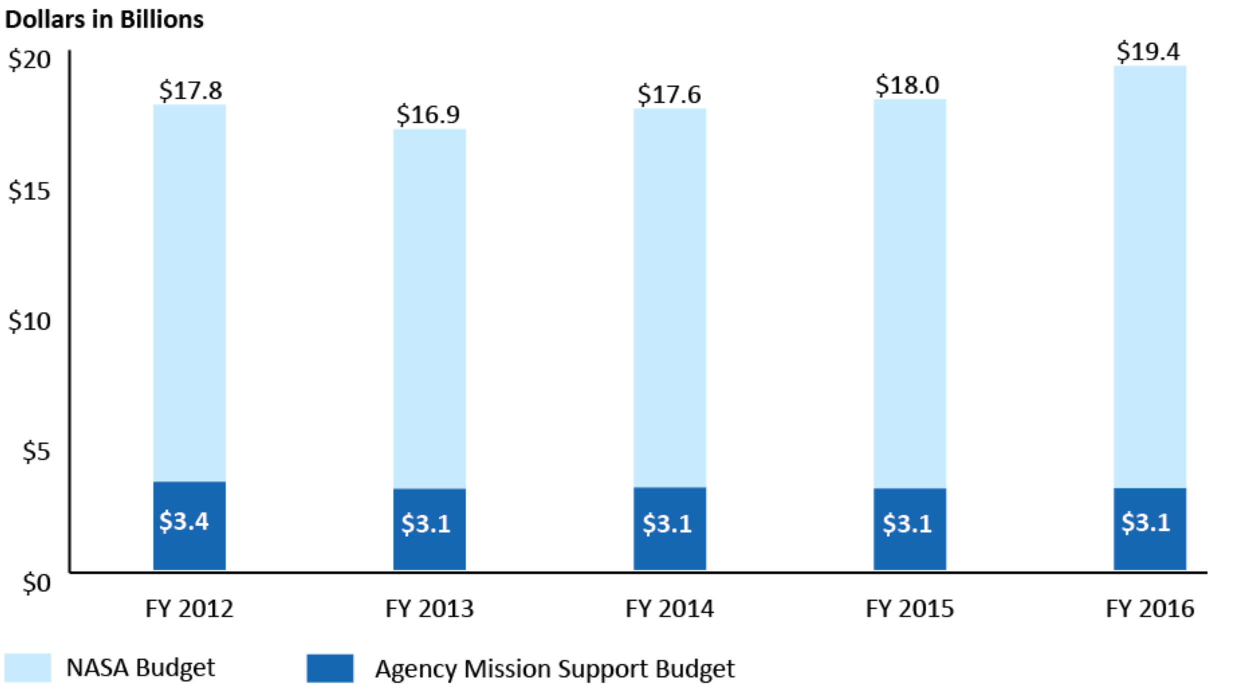


Source: NASA OIG analysis of Agency data.

Insufficient Facilities Budget

NASA's facilities budget has not been sufficient to keep up with necessary maintenance on its old and degrading infrastructure. As shown in Figure 4, although the Agency's overall budget has fluctuated over the last 5 years from a low of $16.9 billion in fiscal year 2013 to a high of $19.3 billion in fiscal year 2016, the portion of its budget that supports facility maintenance and replacement has remained relatively stagnant at approximately $3.1 billion annually. Moreover, according to Agency officials, maintenance funds may be vulnerable to reallocation when higher priority projects require additional funding.

Figure 4: Mission Support and Agency Budget Trends



Source: NASA OIG analysis of Agency data.

Strategically Managing Technical Capabilities is a Long-Standing Challenge for NASA

NASA's ability to manage its infrastructure has been a long-standing challenge, and the Agency has made a number of mostly unsuccessful efforts over the years to rightsize its footprint. For example, in 1996 GAO reported NASA would not meet its internal goal of reducing infrastructure by 25 percent by the end of the decade.[10] Furthermore, as we reported in our 2013 audit, NASA did not take action in response to a 2005 internal study commissioned by the Administrator following the end of the Space Shuttle Program that recommended closing or consolidating three Centers and three component sites.[11] We also identified 33 facilities costing more than $43 million to maintain in fiscal year 2011 that the Agency was not fully utilizing or for which it could not identify a future mission use.[12]

Best Practices for Successful Rightsizing Initiatives

Through a series of reports examining large organizations in the public and private sectors, GAO identified the best practices of organizations that have successfully undertaken rightsizing initiatives.[13] GAO also studied infrastructure issues across the Federal Government and found that agencies continue

---

[10] GAO, "NASA Infrastructure: Challenges to Achieving Reductions and Efficiencies" (GAO/NSAID-96-187, September 1996).

[11] NASA Draft Report, "Real Property Mission Analysis," July 2005. The report was not finalized.

[12] IG-13-008.

[13] GAO "Best Practices: Elements Critical to Successfully Reducing Unneeded RDT&E Infrastructure" (GAO/NSIAD/RCED-98-23, January 8, 1998), and "Military Bases: Lessons Learned from Prior Base Closure Rounds," (GAO/NSIAD-97-151, July 25, 1997).

to experience difficulty disposing of unneeded property because they have not adequately addressed such issues as legal constraints, financial limitations, and stakeholder influences.[14] These issues became the driving force behind the Base Realignment and Closure (BRAC) Commission, a congressionally authorized process the Department of Defense uses to rightsize its military assets. The BRAC process has resulted in the closure of more than 350 Department of Defense installations and produced recurring cost savings of approximately $7 billion annually since 2001. In its work, GAO identified key elements of the BRAC process that could be applicable to civilian agencies.[15] Although NASA did not intend TCAT and CLM to replicate the BRAC, based on GAO's analysis we identified six best practices applicable to our review of the Agency's ongoing rightsizing efforts:

1. *Complete and accurate data.* Obtain comparable and accurate data to help ensure analysis is complete and recommendations are sound.
2. *Core missions.* Define core missions first to ensure organizations focus on infrastructure and workforce in support of missions.
3. *Firm goals.* Establish firm goals to give direction and purpose and allow observers to gauge progress and success of efforts.
4. *Independent analysis and decision making.* Ensure independence of the teams to allow decision makers to be objective and free from parochial or political pressures.
5. *Implementation timeframes.* Create specific timeframes to implement decisions and complete implementation actions to spur activities to move forward in a timely manner.
6. *Standardized guidance.* Use standardized guidance to ensure criteria used, data gathered, and analyses performed are consistently applied and interpreted.

NASA's Efforts to Manage Technical Capabilities

NASA's Associate Administrator established the TCAT in June 2012, envisioning it as a strategic process by which leadership could reassess overall mission implementation and supporting technical capabilities from an integrated, Agency-wide perspective. He also sought to free up funds in the Agency's institutional budget by eliminating technical capabilities that were no longer needed in order to invest in capabilities required for current and future mission needs. In April 2015, NASA replaced TCAT with CLM to institutionalize capability management into the Agency's annual planning and budgeting processes. As of September 2016, NASA has made 37 formal decisions regarding various technical capabilities as a result of the TCAT and CLM initiatives. The initiatives also spawned other efforts to improve the effectiveness of NASA's operating model and address systemic issues such as reducing competition among Centers and Agency scientists for work and improving strategic workforce hiring.

Technical Capabilities Assessment Team

NASA's Associate Administrator led the TCAT initiative with participation from the Agency's Mission Directorates and Centers. The Associate Administrator established a six-person core team composed of individuals from Headquarters and the Centers. The early phase of the process included an evaluation of lessons learned from previous rightsizing initiatives and the development of a framework for how the

[14] GAO "Federal Real Property: Proposed Civilian Board Could Address Disposal of Unneeded Facilities" (GAO-11-704T, June 9, 2011).

[15] GAO-11-704T.

process would operate. The core team also worked to develop a "common lexicon" so that all parties would be operating with the same understanding of important terms. For example, the team defined an "asset" as any item of economic value owned by NASA and identified a list of "solution sets" or systems, subsystems, and activities needed by NASA for a project or mission. The solution sets were categorized consistent with three major themes that describe how the Agency translates strategic goals into implementing constructs in aeronautics, basic research, and space. For example, a mission to discover Earth-like worlds consists of research solutions such as astrophysics and space solutions such as spacecraft and ascent transportation. Technical capabilities are the workforce and assets necessary to perform the work to construct a particular solution. Centers identified the level of engagement and priority they contribute to each solution set, and Mission Directorates provided a high-order assessment of their current, near-term, and long-term need for operational capability from each solution set. Based on this data, as shown in Figure 5, the Agency selected 16 solution sets for a "deep dive" assessment.

Figure 5: Selected TCAT Solution Sets for Deep Dive Assessment

- Aircraft Operations
- Balloons and Airships
- Earth Science Research
- Entry, Descent, and Landing
- Environments Testing
- Extraterrestrial Surface Systems
- Human Factors
- Life Science Research
- Long-term Data Management
- Microgravity Flight Services
- Mission Operations
- Nuclear Power and Propulsion
- Propulsion
- Rendezvous and Docking
- Sensors Systems
- Space Environments Test

Source: NASA OIG presentation of Agency data.

The primary goal of the deep dive assessments was to identify technical capabilities in which there were no current or future mission needs, assess whether there was sufficient capability outside NASA to handle the issue, and determine if there was unnecessary duplication or excess capacity across Centers. To complete the assessments, NASA assembled teams of subject matter experts for each area including individuals from the core team, affected Centers and Mission Directorates, and individuals with expertise in business, policy, and institutions.

The core team developed the TCAT Deep Dive Assessment Handbook (Handbook) to guide the individual teams in organizing and executing their assessments.[16] According to the Handbook, the first step was to develop a study plan outlining the purpose, background, relevant guidance, team responsibilities, methodology, and projected schedule. The teams were then to collect and review relevant background data, including prior internal or external studies, and current Agency policy to determine if standards were consistent or gaps existed. Finally, the teams were to gather data from both the Centers and Mission Directorates related to the facilities, equipment, and personnel working in the specific capability they were reviewing. The teams were also instructed to assess the extent to which the capability would be needed or used in the future to meet mission goals. Each deep dive assessment was to include elements of audit and analysis, including determining requirements and technical capabilities needed to meet demands and evaluating how current technical capabilities were aligned to fulfill that demand. Additionally, the teams were instructed to collect data and conduct site visits, interviews, and other activities as necessary.

[16] NASA, "TCAT Deep Dive Assessment Handbook" (draft), August 2014. The Handbook was never finalized.

In the fall of 2014, the deep dive assessment teams presented their observations to the Centers, Mission Directorates, and the Capability Steering Committee led by the Agency's Deputy Associate Administrator. The Committee served as the clearinghouse for all TCAT information, considering the teams' observations, developing options and recommendations, and preparing "decision packages" for consideration by the Mission Support Council (MSC) – NASA's senior decision-making body for all aspects of its mission support portfolio.[17] The MSC had the authority to make decisions and direct action regarding the packages, after which it would assign particular Centers or other Agency organizations, known as "owners," responsibility for implementing its decisions.[18]

Capability Leadership Model

NASA transitioned from TCAT to the CLM in April 2015 largely to institutionalize capability management into the Agency's annual planning and budgeting processes. With regard to the various technical capability areas, NASA's Office of the Chief Engineer is responsible for managing the discipline and system capabilities; the research capabilities are divided among the Aeronautics Research Mission Directorate (Aeronautics Research), the Office of the Chief Scientist (Life Sciences), and the Science Mission Directorate (Astrophysics, Earth Science, Heliophysics, and Planetary), while the Mission Support Directorate is responsible for the service capabilities.[19]

The Chief Engineer appointed senior technical experts from the NASA Engineering and Safety Center (Technical Fellows) as the Technical Capability Leaders for each of the discipline and system capabilities. According to the Chief Engineer, he chose the Technical Fellows for this role both for their expertise and because they are viewed as "independent" from the NASA Centers. The Mission Support Directorate, Office of the Chief Scientist, and Science Mission Directorate appointed Technical Capability Leaders either by selecting a subject matter expert from within their organization or by advertising for and hiring an individual.

Technical Capability Leaders act as advisors and provide senior NASA management with a strategic perspective on the current and future health of their capability and its ability to meet long-term mission needs. Each Capability Leader is assisted by a team composed of a representative from each Center that conducts work in the capability area. The CLM teams are responsible for advising and ensuring alignment across Mission Directorates and Centers consistent with Agency and capability needs. Specifically, they are to determine capability sizing and strategic hiring to avoid excess capacity, determine gap areas, assess opportunities for investments and divestments within the capability area, and solicit ideas related to technical content, new approaches, workforce skills, asset use, and disposition.[20]

---

[17] NASA Mission Support Council Decision Criteria Package, "Technical Capability Decisions Arising from Capability Steering Committee/Technical Capability Assessment Team" February 27, 2014.

[18] The Deputy Associate Administrator, Associate Administrator, Associate Administrator for Mission Support, Chief Financial Officer, Chief Information Officer, and Chief of Safety and Mission Assurance are members of the MSC.

[19] As noted above, NASA was making changes to its capability areas and types during our review. Some of these changes will result in adjustments to management responsibilities.

[20] NASA, Capability Leadership Model Decision Paper, "Institutionalizing Technical Capabilities Assessment Team," April 2015.

The Office of the Chief Engineer provided the following guidelines to the discipline and system Technical Capability Leaders:

- Establish a leadership model for each capability to operate as an Agency-wide integrated team.
- Align the teams with current and future Agency needs while considering:
    - evaluations of current projects and activities, and recommended changes;
    - rightsizing the workforce to ensure proper balance for civil servants and contractors to support needs, and establishing those roles that should be done in-house and those that can be done by a contractor; and
    - decisions for acquiring products or services.
- Consider changes to the current operating model and implementation strategy for the capability that would provide for greater efficiency.
- Conduct a detailed facilities review and identify duplication and utilization efficiencies.
- Recommend cost savings or efficiencies with a potential range from 10 to 25 percent, depending upon the scale and scope of the capability.
- Evaluate the top challenges and suggest a course of action to address each need.[21]

The Chief Engineer informed the teams that because fiscal year 2015 was the first time they would undertake the CLM process, it would be considered a "baselining" year. Specifically, the teams were to focus primarily on characterizing each Center's work, obtaining facility and workforce demographics, identifying gaps or overlaps, and developing recommendations. The expectation was that CLM would be an iterative process and that in future years the teams would identify changes from the baseline, including the quality of the capability, facility utilization, external availability, partnerships, collaborations, and emerging innovations.

According to the Chief Engineer's guidelines, each year Technical Capability Leaders and their teams are to assess their capability and develop recommendations to produce a "State of the Capability Report" that includes workforce and facility information, identifies gaps or overlaps, and provides challenges and recommendations. Each report is briefed to the Extended Engineering Management Board, chaired by the Chief Engineer and staffed by the Engineering Directors or Chief Engineers from each Mission Directorate and Center and other Headquarters representatives. The Board provides a forum for coordination, integration, and communication across the technical capability areas, and reviews the results of each Technical Capability Leader's presentation and recommendations and consolidates them into an overall Integrated Engineering Discipline Capability Report.

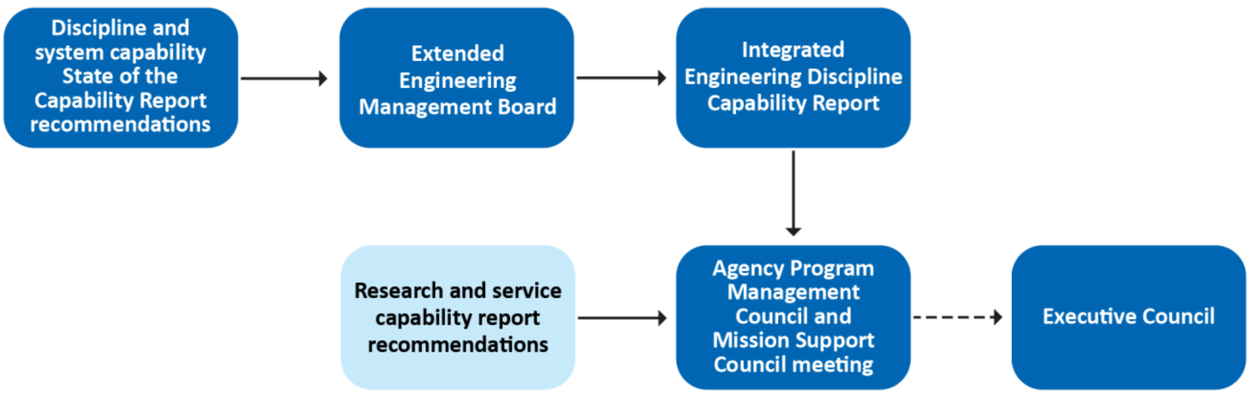
The research and service Technical Capability Leaders were given varying direction regarding how to proceed with their assessments. For example, Aircraft Operations had an existing process in place to annually monitor and assess aircraft, and the Mission Support Directorate instructed the team to use that process to conduct the capability assessment. Other Technical Capability Leaders were given direction by the MSC based on observations the corresponding TCAT deep dive assessment teams had made. Finally, some of the research and service Technical Capability Leaders were given the Chief Engineer's guidance to use as a starting point.

---

[21] Office of the Chief Engineer, "Technical Capability Leadership: Technical (Discipline) Assessment Process," February 2015, and "Technical Capability Leadership Mid-Point Discussion, Presentation to the Engineering Management Board," June 4, 2015.

The Integrated Engineering Discipline Capability Report and reports from the various research and service capability teams are presented annually to the Agency Program Management Council (APMC). Chaired by the NASA Associate Administrator, the APMC serves as the Agency's senior decision-making body regarding all programmatic activities and program-related issues.[22] The APMC baselines and assesses the performance of NASA programs and projects and ensures implementation and compliance with program and project management requirements. The APMC may initiate a joint meeting with the MSC to discuss recommendations that affect both programmatic and institutional areas. Additionally, the APMC may provide strategic, cross-cutting recommendations to the Executive Council, which is chaired by the Administrator and is NASA's highest decision-making body.[23] The Executive Council makes decisions about sensitive, highly visible investment or divestment recommendations such as changes to the Agency's strategic goals or the budget structure of a Mission Directorate. Figure 6 details the decision-making process.

Figure 6: Technical Capability Leadership Decision-Making Process



Source: NASA OIG analysis of Agency information.

TCAT and CLM Efforts to Date

Between June 2012 and September 2016, the Executive Council, APMC, and MSC made 37 formal decisions regarding various technical capabilities ranging from investing in life sciences and other facilities, consolidating capability areas, and divesting assets.

For this audit, in addition to reviewing all 37 formal decisions, we examined 6 TCAT and 15 CLM assessments in detail. All of the assessments in our sample pertained to discipline capabilities and were therefore under the purview of the Chief Engineer.

[22] APMC members include the Deputy Associate Administrator, Chief Engineer, Chief of Safety and Mission Assurance, Associate Administrators of NASA's five Mission Directorates, Center Directors, Chief Financial Officer, Chief Information Officer, Chief Health and Medical Officer, Chief Scientist, Chief Technologist, and General Counsel.

[23] Executive Council members include the Deputy Administrator, Associate Administrator, Deputy Associate Administrator, Chief of Staff, Chief Financial Officer, Chief Scientist, and Chief Technologist.

Other NASA Initiatives

The TCAT and CLM initiatives spawned other efforts to improve NASA's operating model and address systemic issues related to competition, program and project management, and other strategic issues identified by NASA senior leadership. For example, NASA's Business Services Assessment followed the same approach as TCAT with a focus on the Agency's information technology, procurement, human capital, budget management, and facilities functions. Another effort examined the issue of Centers competing against one another for program and project work. A third effort involved NASA senior managers working to streamline internal Agency program and project management practices by analyzing sample projects to gauge whether NASA was imposing unnecessary constraints and requirements to the program management process and examining planning, tracking, and accounting requirements associated with allocating civil servants to programs and projects, as well as the planning and tracking of workforce assignments. The fourth effort established an annual Agency Strategic Integration Planning meeting to assist in development of NASA's budget request. This meeting is an additional forum for NASA senior leadership to discuss the Technical Capability Leadership process, gain insights into technical capabilities that may be over- or under-subscribed, and examine potential efficiencies in managing technical capabilities. Lastly, NASA established an Agency Integration Team to coordinate strategy and policy across several key areas, including acquisition strategies, capabilities leadership and alignment, strategic workforce planning, and Agency architecture. The Agency Integration Team is also developing detailed mission data to ensure better alignment with Agency strategic objectives.

ADJUSTMENTS TO FRAMEWORK SHOULD IMPROVE NASA'S ABILITY TO MANAGE ITS TECHNICAL CAPABILITIES, BUT OLD AND NEW OBSTACLES POSE CHALLENGES

Through the TCAT and CLM processes, NASA has established a framework that should improve the Agency's ability to manage its technical capabilities and help make the difficult decisions regarding infrastructure and personnel required to optimally position itself for current and future missions. While NASA has taken initial steps toward rightsizing its infrastructure, after more than 4 years the Agency has yet to make many concrete decisions – for example, to consolidate or dispose of assets. Moreover, we found NASA's assessments of its current capabilities did not consistently include information needed to make informed decisions, including mission needs or facility usage data, analyses to determine gaps or overlaps, or recommendations to achieve cost savings. In addition, NASA did not incorporate in its process the best practices we identified from BRAC and other successful rightsizing efforts, including following standardized guidance, incorporating independent analysis and cost-benefit rationales, and setting firm timeframes for completing actions. Finally, NASA continues to face the long-standing challenges of its federated governance model, uncertainty about its direction and future missions, political influence, and the lack of institutionalized processes that have hindered past Agency efforts to strategically align its technical capabilities. Adjusting its framework to include the omitted information and best practices – coupled with resolve from NASA leaders to make difficult and at times unpopular decisions and engage stakeholders to support or at least not attempt to thwart these decisions – would improve the chances the CLM process will lead to a better match between the Agency's technical capabilities and its current and future missions.

Development of NASA's Capability Leadership Framework is a Positive Step

NASA's capability leadership framework has positioned the Agency to make more informed decisions about its technical capabilities. However, because it has the potential to result in shuttering facilities and restructuring the workforce, capability leadership can be a difficult and controversial process. We are encouraged the Associate Administrator – NASA's third-ranked official and most senior civil servant – is leading the effort and that he readily acknowledges and accepts the challenges associated with implementing such a large-scale and long-term initiative. Moreover, incorporating capability leadership into the Agency's strategic planning and budgeting processes improves the chances it will receive high-level attention on an ongoing basis and evolve as the Agency and its missions change. Finally, we acknowledge the level of effort the Agency has taken to make the CLM process transparent to both internal and external stakeholders. By involving internal stakeholders and working to educate external stakeholders about the process, NASA management has improved the chances of reaching a common understanding about the technical capabilities that will be required to support the Agency's current and future missions.

Early Efforts Resulted in Few Concrete Decisions

Although NASA officials envisioned TCAT and CLM resulting in decisions that would free up resources for future mission needs, to date the Agency has made relatively few such determinations. Of the 37 decisions the Executive Council, APMC, and MSC have made since June 2014, only 13 involved investing, divesting, or consolidating infrastructure or personnel supporting particular technical capabilities.[24] Although we are not suggesting the success of the Agency's progress should be based solely or even primarily on this factor, we are concerned about the slow pace of the process and the absence of such decisions makes it difficult to determine whether the process will ultimately lead to a better match between the Agency's technical capabilities and its missions.

TCAT Decisions

NASA made only one divestment decision as a result of the TCAT process – to eliminate its Microgravity Flight Services, including the associated C-9 aircraft maintained at Johnson.[25] The Agency's Microgravity Flight Services involved a commercial contract and the C-9 to provide short-duration, reduced-gravity environments for NASA's research and technology development activities. As of January 2016, the C-9 had been taken off active status and moved to a storage facility; however, NASA will retain ownership of the plane until it can be transferred to another Government agency. NASA had not estimated how much it will save by divesting the C-9.

TCAT also resulted in decisions to make additional investments in a number of technical capabilities, including to acquire the National Science Foundation's balloon facility, construct new Life Sciences facilities at Ames and Johnson, and construct a new animal care facility and maintain the lease for the Space Life Sciences Lab at Kennedy. The balloon facility was transferred to NASA in February 2016 at no cost. The Agency plans to spend more than $100 million on the new Life Sciences facilities at Ames and Johnson.[26]

The remainder of the TCAT decisions involved such actions as appointing Technical Capability Leaders, studying particular technical capabilities in order to position the Agency to make decisions about them, and developing an agreement with the Department of Energy to revise roles and responsibilities related to nuclear hardware development. Although these administrative decisions may have been necessary steps to reach decisions regarding particular technical capabilities, they did not result in any investment, divestment, or consolidation of NASA resources or other concrete actions relating to particular technical capabilities. Table 1 describes each of the 19 decisions made as a result of the TCAT process and their status.

[24] NASA also utilizes processes outside of TCAT and CLM in order to make investment or divestment decisions, such as the Center master planning process used to assist in developing Center budgets and program and project plans, as well as aligning Centers with Agency missions and goals.

[25] According to NASA officials, the TCAT process also enabled additional aircraft divestments, including 20 manned aircraft and 59 unmanned aircraft systems.

[26] As of February 2017, Congress had not appropriated all of the funds for the facilities.

Table 1: TCAT Decisions Made in 2014 and 2015

Capability Area and Description	Decision Authority (Date)	Decision Type	Implementation Status
Aircraft Operations			
Review T-38 aircraft capability	MSC (June 2014)	Administrative	Implemented
Establish capability leadership for Aircraft Operations	MSC (June 2014)	Administrative	Implemented
Balloons			
Evaluate alternative approaches for balloon launches	MSC (Apr. 2014)	Administrative	Implemented
Acquire National Science Foundation balloon facility	MSC (Aug. 2015)	Investment	Implemented
Earth Science			
Review Earth science data information systems	MSC (July 2014)	Administrative	Implemented
Establish capability leadership for Earth Science	MSC (July 2014)	Administrative	Implemented
Environments Testing			
Establish capability leadership for Space Environments Testing	MSC (Feb. 2015)	Administrative	Implemented
Human Factors			
Establish capability leadership for Human Factors Capability	MSC (Sept. 2014)	Administrative	Implemented
Life Sciences			
Construct new Life Sciences facilities at Ames and Johnson	MSC (July 2014)	Investment	Ongoing
Construct a new animal care facility and maintain the lease for the Space Life Sciences Lab at Kennedy		Investment	Implemented
Establish capability leadership for Life Sciences		Administrative	Implemented
Determine how Life Science Capability Leadership will report to APMC	MSC (July 2014)	Administrative	Implemented
Microgravity Flight Services			
Divest of internal Microgravity Flight Services, including C-9 aircraft	MSC (April 2014)	Divestment	Implemented
Delay divestment of C-9 until commercial vendor is identified	MSC (Sept. 2014)	Administrative	Implemented
Divest of C-9 by December 2015	MSC (Mar. 2015)	Administrative	Implemented
Delay C-9 divestment until February 2016	MSC (Dec. 2015)	Administrative	Ongoing
Mission Operations			
Appoint a leader to review distribution and management of Mission Operations	MSC (Oct. 2014)	Administrative	Implemented
Nuclear Power and Propulsion			
Establish a subject matter expert for Nuclear Power and Propulsion	MSC (Jan. 2015)	Administrative	Implemented
Develop an agreement with the Department of Energy on nuclear systems		Administrative	Implemented

Source: OIG analysis of NASA data.

NASA officials told us they believe TCAT did not result in significant investment, divestment, or consolidation decisions because it was an initial attempt to baseline the capability areas and ease the Centers and other stakeholders into the concept of capability leadership. They also said they recognized alignment of the Agency's technical capabilities would need to occur over time and that a more enduring process will be required to continuously address these capabilities from an Agency-wide perspective. As discussed previously, the Agency moved to CLM in an attempt to address these longer-term issues.

Capability Leadership Model Decisions

As of September 2016, the CLM process had resulted in 18 decisions relating to the capability areas of Aerosciences, Avionics, Electrical Power, Flight Mechanics, Life Sciences, Materials, Propulsion, and Space Environments Testing. Seven of these decisions called for divestment or consolidation of assets, including consolidating propulsion test facilities at Glenn and Marshall, consolidating composite materials processing facilities at Marshall and the White Sands Test Facility (White Sands), and divesting infrastructure used to conduct research and produce lithium ion battery cells at Johnson in favor of relying on private industry for this technology. As of November 2016, Glenn planned to demolish 14 buildings, which officials expect to result in $260,000 in cost avoidance, and reactivate one building to support testing activities. In addition, NASA is moving materials processing equipment from Marshall to White Sands, a move officials estimate will generate approximately $400,000 in long-term savings.

Two of the CLM decisions related to investments. For example, MSC directed reactivation of the Unitary Planned Wind Tunnel at Langley to support testing of the Space Launch System.[27] Before this decision, NASA had planned to demolish the tunnel. MSC also directed an assessment of whether a viable replacement for the tunnel can be identified.

The remaining nine decisions were iterative steps on the path to making decisions about technical capabilities. For example, in November 2015 MSC established a Space Environments Testing CLM in the Mission Support Directorate to centralize leadership of space environment testing assets and review facility management and usage in light of long-term needs and workforce sustainment. Other decisions formalized an internal agreement for battery testing, produced a plan to address the workforce issues that resulted from the lithium-ion battery cell divestment decision, accelerated the on-going consolidation of flight mechanics infrastructure at Langley, and developed a plan to coordinate and consolidate existing chemical propulsion capabilities.

As of October 2016, NASA had fully implemented 2 of the 18 CLM decisions and the remainder were in various stages of implementation. Table 2 describes each of the 18 formal decisions taken as a result of the CLM process and their status.

[27] The Space Launch System is a heavy-lift launch vehicle planned to launch NASA's Orion spacecraft and other systems beyond low Earth Orbit.

Table 2: CLM Decisions Made between 2015 and 2016

Capability Area and Description	Decision Authority (Date)	Decision Type	Implementation Status
Avionics			
Consolidate electronic parts expertise	EC (Nov. 2015)	Investment/ Divestment	Ongoing
Electrical Power			
Formalize agreement for battery cell testing	EC (Nov. 2015)	Administrative	Implemented
Divest and rely on industry for lithium ion battery cells.	EC (Nov. 2015)	Divestment	Implemented
Address workforce shift as a result of battery cell decisions	APMC (June 2016)	Administrative	Ongoing
Flight Mechanics			
Accelerate Flight Mechanics consolidation at Langley	EC (Nov. 2015)	Administrative	Ongoing
Materials			
Divest of the Material Compatibility, Flammability, and Toxicity Testing at Marshall and consolidate at White Sands	EC (Nov. 2015)	Investment/ Divestment	Ongoing
Propulsion			
Develop a plan to coordinate and consolidate existing chemical propulsion	EC (Nov. 2015)	Administrative	Ongoing
Consolidate propulsion testing facilities at Marshall	EC (Nov. 2015)	Investment/ Divestment	Ongoing
Develop a plan to coordinate and consolidate existing green propulsion	EC (Nov. 2015)	Administrative	Ongoing
Develop a plan to address duplication of Thrust Vector Control labs at Marshall and Glenn	EC (Nov. 2015)	Administrative	Ongoing
Develop a plan to coordinate and consolidate existing electric propulsion	EC (Nov. 2015)	Administrative	Ongoing
Consolidate propulsion test facilities at Glenn	EC (Nov. 2015)	Investment/ Divestment	Ongoing
Aerosciences			
Reactivate Unitary Plan Wind Tunnel	MSC (Aug. 2016)	Investment	Ongoing
Space Environments Testing			
Divest 20 assets, mothball 6 assets and perform further analyses	MSC (Sept. 2015)	Divestment	Ongoing
Move towards a centralized management model	MSC (Nov. 2015)	Administrative	Ongoing
Divest of 1 asset and perform further analyses	MSC (Mar. 2016)	Divestment	Ongoing
Refer assets to CLM teams to review	MSC (May 2016)	Administrative	Ongoing
Life Sciences			
Increase workforce ceiling at Ames	MSC (May 2016)	Investment	Ongoing

Source: NASA OIG analysis of Agency data.

Note: EC stands for Executive Council.

NASA officials characterized CLM as still in the early stages and said that, as with TCAT, the initial focus of the effort was to establish baselines for each capability area. As noted earlier, CLM is intended to be an ongoing process, and officials anticipate additional decisions will be implemented and future assessments will lead to more concrete decisions to consolidate or divest assets or make additional investments in specific technical capabilities.

Initial Assessments Did Not Include Data Necessary to Make Informed Decisions

Many of the TCAT and CLM assessments did not include information required by the TCAT Handbook and the Chief Engineer's guidelines. Without this information it will be difficult for NASA to make informed decisions about its technical capabilities. Most of the 21 assessments we reviewed lacked one or more data points or analyses, such as information about mission needs or facility usage, analysis regarding gaps or overlaps in facilities or workforce, or recommended actions to achieve cost savings goals.[28] Although the TCAT and CLM guidance called for detailed facility reviews, analyses of workforce, and identification of duplication and cost savings, CLM team members we spoke with said specifics regarding how to gather and analyze this information were not provided or unclear.[29] Moreover, CLM team members reported having insufficient time and resources to gather all required information and conduct the required analyses. We also found the TCAT and CLM processes did not incorporate many of the best practices we identified from BRAC and other successful rightsizing efforts, including obtaining accurate and complete data, defining core missions, using standardized guidance, establishing firm goals and implementation timeframes, and ensuring independent analysis and decision making.

Incomplete Data

None of the TCAT or CLM teams whose work we reviewed obtained detailed information on future missions despite the TCAT Handbook and Chief Engineer's guidance. Furthermore, 4 of the 6 TCAT and 13 of the 15 CLM teams did not obtain information regarding the usage or condition of the facilities that support their capability.

Information about the types of current and future work the Agency will conduct helps decision makers determine which facilities and people are needed to accomplish those missions. TCAT team members and the CLM Technical Capability Leaders we spoke with said they worked with the Mission Directorates to identify high-level mission requirements for the Directorates' programs and projects, but were mostly unable to get detailed data broken out by individual facility or beyond a 1- or 2-year horizon. In lieu of this more detailed data, they attempted to use, for example, conceptual design studies of possible missions to Mars, but found the data unclear or not fully defined. For instance, knowing that the Agency is planning a mission to the vicinity of Mars in the 2030s without details about whether it will be a fly-by or a landing mission on the planet or one of its moons makes it difficult to plan the technical capabilities and therefore the resources that will be needed. Similarly, the TCAT and CLM teams did not obtain

---

28 We reviewed 6 TCAT assessments and 15 discipline CLM assessments. The discipline assessments were under the purview of the Office of the Chief Engineer.

29 NASA Mission Support Council Decision Criteria Package, "Technical Capability Decisions Arising from Capability Steering Committee/Technical Capability Assessment Team" February 27, 2014; "TCAT Deep Dive Assessment Handbook-DRAFT," August 2014; Office of the Chief Engineer, "Technical Capability Leadership: Technical (Discipline) Assessment Process," February 2015; and "Technical Capability Leadership Mid-Point Discussion, Presentation to the Engineering Management Board," June 4, 2015.

mission data for all of the facilities that support their capability areas. They explained that either the data did not exist or there was insufficient time to obtain it. Without detailed mission data, CLM Technical Capability Leaders were unable to determine if programs or other customers were likely to utilize individual facilities.

It is clear from successful rightsizing efforts that an organization first needs to make decisions regarding its core missions before it can accurately identify the infrastructure needed to support those missions. Failing to define core missions often leads to efforts to "find" work or create links to other missions in order to justify a capability's existence. To their credit, NASA leaders recognized the need for a more defined roadmap to articulate mission needs and, in 2015, stood up the Agency Integration Team to address this and other strategic issues. The Integration Team is in the process of meeting with each of the Mission Directorates to coordinate future mission needs from a cross-directorate perspective. Although in the early stages, we see this effort as a positive step and believe timely completion of the planned roadmap will improve future capability assessments.

We also found that 4 of the 6 TCAT teams and 13 of the 15 CLM teams whose work we reviewed did not obtain data related to the condition or usage of the facilities that support their capability areas. While all teams were able to identify the inventory and physical location of the facilities, they did not compile usage or condition information. Without this data, it is difficult to make informed decisions about possible duplication among facilities or identify facilities that have outlived their design lives. TCAT and CLM team members we interviewed explained they either did not have sufficient time to gather facility usage or condition data or the data they obtained from the Centers was incomplete and unusable. In addition, they said they believed the primary purpose of the first assessments was to obtain an accurate inventory and that more detailed data about use and condition would be obtained in future assessments. While we understand that the first year of assessments was a starting point, obtaining, analyzing, and ensuring the accuracy of data is a key element to effective rightsizing endeavors and something NASA will have to improve upon if its efforts are to succeed.

Lack of Workforce and Gap Analyses

We found that none of the TCAT teams and only one CLM team performed analyses on the workforce associated with their capability as required by the TCAT Handbook and Chief Engineer's guidance. While all teams identified the number of civil servants and contractors in their respective capability areas, with one exception they did not analyze whether this workforce matched Agency needs. For example, Capability Leaders were instructed to examine the size and scope of civil servant and support contractor hiring to identify potential duplication or excessive use of contractors. Similarly, TCAT teams were instructed to assess whether technical capabilities were predominately supported by contractors and, if so, consider whether it was appropriate for the Agency to maintain the capability.

Five of the six TCAT teams and all of the CLM teams whose work we reviewed did not conduct formal analyses to determine if there were gaps or overlap in the infrastructure or workforce associated with their capability area. Both the TCAT Handbook and Chief Engineer's guidance provide that teams should look for gaps or overlap and work to align technical capabilities with Agency needs. In order to do this, teams needed a complete inventory of "what the Agency has" so they could measure it against "what the Agency needs." As discussed previously, although the teams were generally able to gather information about what the Agency has in terms of infrastructure and workforce, without more detailed information about planned missions or utilization it was difficult to measure that information against future needs.

The CLM teams we interviewed told us the written guidance they received was not specific about the types of analyses they should perform or how to perform them and that the guidance evolved over time. Team members said instructions they received late in the process about the types of information to obtain would have been more helpful at the beginning of the process to guide their work. For example, one CLM Technical Capability Leader obtained demographic information for the workforce because he thought it was required, but no other teams obtained this information. According to this Technical Capability Leader, the demographic information is important because it assisted him in identifying where gaps existed in regard to the age of the workforce.

Best practices dictate standardized guidance to ensure the data gathered and analyses performed are consistently applied and interpreted. Without standardized guidance to perform detailed gap and workforce analyses, the teams were unable to assess the overall health of the capability and whether it is appropriately sized.

Lack of Recommendations to Achieve Cost Savings Goal

The Office of the Chief Engineer set a cost savings goal of 10 to 25 percent for the various CLM teams under its purview.[30] However, officials told us they did not expect the teams to hit the targets and that they set these goals simply to push teams to look for savings. We found that although the teams made some cost savings recommendations – for example, suggesting NASA procure Agency-wide site licenses for development tools and make bulk purchases of flight components – with one exception none of those recommendations met the 10 to 25 percent goal. Indeed, most of the teams that made cost savings recommendations did not quantify how much savings they expected these actions to achieve.

The CLM Technical Capability Leaders we interviewed gave multiple reasons for not making recommendations conforming to the savings goal. First, some thought the goal was unrealistic and that the only way to achieve it was to reduce workforce, a decision they did not believe could be made before the Agency more clearly defined its future missions. Others said their capability areas had already been “hit hard” by budget cuts and were operating with a bare bones staff. Finally, some indicated their Centers were reluctant to identify assets for potential divestment and that any recommendations their team made related to “low hanging fruit” that did not generate significant cost savings.

Best practices state that establishing goals gives direction and purpose to a right-sizing initiative. Accordingly, we believe that going forward NASA should continue to set cost savings goals and CLM teams should make every effort to respond to them.

Implementation Plans for CLM Decisions Lack Timeframes for Completion

NASA officials developed implementation plans for each of the decisions that resulted from the CLM process; however, not all of the plans contained dates by which the underlying actions were expected to be implemented.[31] For example, the implementation plan for the decision to coordinate and consolidate the Agency’s electric propulsion research and development efforts does not contain a date by which the Agency expects to finalize its efforts or a corresponding timeline for interim steps.

---

[30] The TCAT teams did not have an established cost savings goal.

[31] All but two TCAT decisions have been implemented.

Although we acknowledge that consolidating activities can take time and may occur in multiple phases, establishing firm timeframes is a key element of successful rightsizing initiatives. Without deadlines, the process is more susceptible to delays or disuse.

Independent Analysis and Decision Making

We found the 15 CLM teams lacked sufficient independence because they were located and worked at the Centers they were tasked with assessing. NASA's Associate Administrator explained the CLM Technical Capability Leaders were the heads of the capability areas within the NASA Engineering and Safety Center and that the Agency considered them independent because although they are physically located at a Center, their positions are funded at the Agency level. However, the Technical Capability Leaders we spoke with said team members vetted data and potential recommendations with Center management before providing the information to them and that team members were hesitant to identify facilities for divestment because of their desire to protect Center assets.

In contrast to the CLM structure, both the TCAT and Business Services Assessment teams were more independent.[32] For Business Services Assessment teams, the team leader is a customer of the service being assessed and the deputy team leader is a technical expert from the area. Additionally, half of the team members are from outside the discipline. The TCAT teams were also composed of individuals from inside and outside the technical capability areas and from different Centers. Establishing teams with a mix of individuals from inside and outside the discipline helps ensure capability teams are not protecting particular assets. Furthermore, according to best practices, independent analysis and decision making ensures objectivity and allows team members and decision makers to be free from parochial and political pressures.

NASA Continues to Face Long-standing Challenges that Have Hindered Previous Rightsizing Efforts

Four longstanding challenges have hindered previous Agency efforts to strategically align its technical capabilities and continue to threaten the success of the Agency's CLM effort: NASA's federated governance model, uncertainty about its direction and future missions, political influence, and the lack of institutionalized processes. To its credit, NASA has taken steps to address these challenges, including efforts to minimize competition for work among the Centers and Agency scientists, develop a more defined roadmap to articulate mission needs, and socialize technical capability efforts with outside stakeholders. In addition, NASA intends to codify the CLM process into Agency policy.

Federated Governance Model

NASA's federated governance model has encouraged Centers to build up and maintain technical capabilities so they are in a position to compete for work on Mission Directorate programs and projects.[33] The bulk of the Agency's budget is distributed to programs and projects, which rely on the facilities and workforce at the Centers to complete their work. As a result, Centers maintain their

[32] The Business Services Assessment teams conduct reviews in the Agency's administrative discipline areas such as human capital and information technology.

[33] IG-13-008.

technical capabilities in a "ready to produce" state in order to be competitive when new work becomes available. Moreover, approximately 40 percent of Agency scientists must compete for Agency research grants to fund their work rather than relying on dedicated Agency funding. Finally, NASA does not engage in Agency-wide, strategic planning for hiring scientists. Rather, individual Centers hire scientists based on their own needs.

To its credit NASA has identified these issues as potential barriers to its capability assessment efforts and in November 2015 the Associate Administrator directed action aimed at addressing them:

1. The Chief Scientist was tasked with proposing a revised model for funding and reviewing the activities of internal scientists and with identifying a revised approach to hiring with the goal of ensuring alignment between the needs and future directions of the Agency's funding organizations and the number and specialties of Center scientists.
2. The Science Mission Directorate was tasked with leading an assessment of the process NASA utilizes to solicit research (Announcement of Opportunity), identify core capabilities for inclusion in upcoming Announcements, establish guidelines to designate lead Centers, and gather lessons learned from the most recent Announcement.
3. Mission Directorates were instructed to specify and document assignments to particular Centers. The assignments must go beyond a "lead Center" and specify the roles of all Centers expected to contribute to each mission.

In March 2016, NASA adopted a new funding model for Agency scientists that ensures 80 percent of civil servant scientists' and support staff funding is covered by non-competed work. Moreover, Centers will coordinate with NASA Headquarters prior to hiring scientists. The Agency plans to have the new funding model adopted by fiscal year 2018. Actions regarding mission competition are also underway and changes to the Announcement of Opportunity practices were implemented in December 2016.

Finally, the Agency established a Strategic Workforce Planning process with the goal of improving how each Center forecasts its workforce capacity based on mission demands and demographic shifts.[34] In October 2016, the working group identified primary and support roles for each Center, as well as the roles that would be phased out at specific Centers. For example, one of Marshall's primary roles is conducting chemical propulsion work – a function the Center will retain – while chemical propulsion technology and advanced development work will be phased out at Goddard. Similarly, Goddard will continue its primary role in Near Earth Communication while Ames and Armstrong will divest this work. Likewise, Goddard and JPL will have primary roles in Agency Avionics technology activities, while this capability will be phased out at Ames, Glenn, and Langley. In addition, Glenn will have a primary role in In-Situ Resource Utilization work, while Kennedy will divest of that activity. NASA leaders hope that this effort to clarify the "swim lanes" for the various Centers will help NASA reshape workforce and supporting infrastructure accordingly. The Agency expects Centers and Mission Directorates to develop implementation plans to conform to the role clarifications by October 2017.

[34] Strategic Workforce Planning emerged as a recommendation from the Human Capital Business Services Assessment and the first decision aligning Center roles relates to competition.

Fluctuating Strategic Direction

Changes to the Nation's space policy initiated by Congress, the President, and NASA have increased the difficulty of determining which technical capabilities the Agency needs to accomplish its mission.[35] For example, NASA's Human Exploration and Operations mission transitioned from the Space Shuttle Program to the Constellation Program to the Space Launch System Program in just 6 years. Because decisions of whether to retain, consolidate, or dispose of specific facilities depend heavily upon the missions NASA undertakes, frequent changes to those missions complicate the task of managing the Agency's technical capabilities. As discussed earlier, CLM Technical Capability Leaders pointed to the lack of detailed mission data as one of the reasons they did not perform comprehensive analyses of capability areas. NASA stood up the Agency Integration Team to address this and other strategic issues.

Political Influence

The political context in which NASA operates often impedes its efforts to reduce Agency infrastructure. In our 2013 report, we noted several examples where political leaders intervened in plans to close or consolidate Agency facilities. For example, members of Congress opposed NASA's decision to consolidate the Agency's arc-jet operations at Ames, directed completion of the A-3 test stand even though the rocket engine for which it was being built had been cancelled, and contested the Agency's decision to seek alternatives for the future use of Hangar One and Moffett Federal Air Field at Ames. While pressure from Federal, state, and local officials with interests in maintaining the health of Federal installations in their jurisdictions is not unique to NASA, it creates additional difficulties for the Agency as it seeks to manage its aging and expansive infrastructure.

NASA officials readily acknowledge the political challenges in executing decisions to consolidate technical capabilities and have taken steps to socialize the TCAT and CLM processes with congressional stakeholders. For example, they held informational briefings with congressional staff in April 2014 to describe the process and have continued to communicate with congressional members and staff both in Washington, D.C., and in local congressional districts as decisions have been made. Even with these outreach and communication efforts, based on past history NASA likely faces significant opposition to decisions about divesting infrastructure or realigning its workforce if the decisions are seen as negatively affecting the health of individual NASA Centers. Consequently, these decisions need to be part of a well-researched and well-documented process that focuses on attainment of NASA's most important missions. Agency officials need to be able to articulate how the process and its resulting decisions will achieve that end.

Institutionalizing CLM

While NASA has attempted infrastructure reduction initiatives in the past with limited success, in our judgment previous efforts have not been successful, in part, because they were never fully institutionalized into policy or the Agency's business practices. Accordingly, in our 2013 report we recommended NASA institutionalize its capability management efforts by establishing them in Agency policy.[36] Agency officials told us they have institutionalized the CLM process by making it an iterative process that feeds into the annual budget process. They also intend to incorporate the process into NASA policy once they have had more experience with it and have had an opportunity to, as one Agency official said, "work out the kinks."

---

[35] IG-13-008.

[36] IG-13-008.

CONCLUSION

A large portion of the infrastructure that supports NASA's technical capabilities is aging, which presents considerable risk to the Agency's overall mission as facilities degrade, become obsolete, and are considerably more expensive to maintain. At the same time, NASA officials readily acknowledge the Agency has more infrastructure than it needs to carry out current and planned missions. TCAT and CLM were established to help the Agency better align both the infrastructure and personnel resources that support its technical capabilities and to free up funds to reinvest in the capabilities needed for current and future missions.

NASA's capability leadership framework has positioned the Agency to make more informed decisions about its technical capabilities, and we are encouraged by the attention senior NASA leadership has devoted to these issues. Nevertheless, we are concerned efforts to date have been slow to produce meaningful results, with most decisions constituting iterative steps on the path to making actual determinations about technical capabilities rather than, for example, decisions to consolidate or eliminate facilities or functions. In our judgment, the Agency's chances of achieving meaningful results would improve if it takes steps to ensure best practices are incorporated in future assessments and that the assessments include all the information needed to make informed decisions, including facility usage, analysis regarding gaps or overlaps, and recommended actions to achieve cost savings.

We believe NASA must continue to press forward with CLM and that Agency leaders should work to further institutionalize the process while continuing their efforts to promote the process both inside and outside the Agency. Ultimately, they must be willing to make difficult decisions to invest, divest, or consolidate unneeded infrastructure; effectively communicate those decisions to stakeholders; and withstand the inevitable pressures from Federal, state, and local officials. Failure to do so increases the risk the Agency will continue to spend valuable resources on unneeded technical capabilities and be unable to deliver the technical capabilities required for future missions.

Recommendations, Management's Response, and Our Evaluation

To ensure NASA's efforts to evaluate technical capabilities are institutionalized and sustained over time, we recommended the Associate Administrator

1. create standardized guidance for performing annual capability assessments that considers, at a minimum, the appropriate time and resources for performing the assessments and the required data, analyses, and expected goals or results;
2. evaluate CLM assessments and teams to better ensure independence;
3. develop and institute training, communications, or other measures to ensure capability assessments are complete, thorough, and include expected goals and results; and
4. revise the CLM decision process to include implementation timeframes for dispositioning agreed upon actions.

We provided a draft of this report to NASA management who concurred with and described planned actions to address our recommendations. We consider the proposed actions responsive and will close the recommendations upon verification and completion of the actions.

Management's response to our report is reproduced in Appendix C. Their technical comments have been incorporated, as appropriate.

Major contributors to this report include, Ridge Bowman, Space Operations Director; Michael Brant, Project Manager; Tekla Colón; Sarah McGrath; Andrew McGuire; and Benjamin Patterson.

If you have questions about this report or wish to comment on the quality or usefulness of this report, contact Laurence Hawkins, Audit Operations and Quality Assurance Director, at 202-358-1543 or laurence.b.hawkins@nasa.gov.

Paul K. Martin
Inspector General

Appendix A: Scope and Methodology

We performed this audit from January 2016 through February 2017 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives. Our overall objective was to review the Agency's plans and progress to strategically manage its technical capabilities required to support Agency goals.

To gain an understanding of the TCAT and Capability Leadership processes, we conducted interviews with Agency Officials including the Associate Administrator, Deputy Associate Administrator, Chief Engineer, TCAT core team members, Technical Capability Leaders, and Mission Directorate and Center officials involved in the process. We reviewed a handbook, memorandums, white papers, and presentations developed and used by the TCAT and CLM teams in performing their assessments.

We judgmentally selected 6 TCAT deep dive assessments and 15 CLM assessments conducted in the 2014 to 2015 timeframe. We also obtained and reviewed all TCAT and CLM decision packages, including the observations and recommendations made by the teams and noted the recommendations formally adopted by the Executive Council, APMC, and MSC. In addition, we reviewed the implementation status and associated cost savings of all adopted recommendations, including those outside of our judgmental sample.

We also reviewed the TCAT and CLM guidance provided to the teams. This guidance included:

- NASA MSC Decision Criteria Package, "Technical Capability Decisions Arising from Capability Steering Committee/Technical Capability Assessment Team," February 27, 2014
- TCAT Deep Dive Assessment Handbook-Draft, August 2014
- Office of the Chief Engineer, "Technical Capability Leadership: Technical (Discipline) Assessment Process," February 2015
- "Technical Capability Leadership Mid-Point Discussion, Presentation to the Engineering Management Board," June 4, 2015

We analyzed each assessment package to determine if it complied with the established guidelines, and whether the analysis was comprehensive. We also compared the TCAT and Capability Leadership processes to best practices we identified from BRAC and other successful rightsizing initiatives.

Use of Computer-Processed Data

We did not use computer-processed data to perform this audit.

Review of Internal Controls

We reviewed and evaluated the internal controls associated with the TCAT and Capability Leadership plans and processes. The control weaknesses we identified are discussed previously in this report. Our recommendations, if implemented, should correct the identified weaknesses.

Prior Coverage

During the last 6 years, the NASA OIG and GAO have issued five reports of significant relevance to the subject of this report. Unrestricted reports can be accessed at http://oig.nasa.gov/audits/reports/FY17 and http://www.gao.gov, respectively.

NASA Office of Inspector General

NASA's Efforts to Reduce Unneeded Infrastructure and Facilities (IG-13-008, February 12, 2013)

NASA Infrastructure and Facilities: An Assessment of Data Used to Manage Real Property Assets (IG-11-024, August 4, 2011)

Government Accountability Office

High Risk Series: An Update (GAO-15-290, February 2015)

Human Capital: DOD Should Fully Develop Its Strategic Civilian Workforce Plan to Aid Decision Makers (GAO-14-565, July 9, 2014)

Federal Real Property: Proposal of Civilian Board Could Address Disposal of Unneeded Facilities (GAO-11-704T, June 9, 2011)

Appendix B: NASA's Technical Capabilities

This Appendix provides a description of, statistics about, and actions NASA has taken in relation to 24 of the 32 capabilities the Agency had identified as of November 2016 during our audit fieldwork.[37] It does not include information for the Agency's eight other capabilities during this period because NASA had just identified them and had not completed related assessments.[38]

Discipline Capabilities

Active Thermal/Life Support

The Active Thermal/Life Support capability develops, tests, and operates active thermal control systems, which acquire, transport, and reject waste heat from spacecraft systems to fluid systems. Additionally, the capability supports a safe and habitable environment for human spacecraft, spacesuits, and rovers. For example, Orion will utilize active thermal/life support systems to acquire and transport waste heat in order to keep crew members safe.

The Orion will use active thermal/life support systems to provide crew protection. Source: NASA.

Participating Centers	Ames, Armstrong, Glenn, Goddard, Johnson, JPL, Kennedy, and Marshall
Assets or Facilities	Numerous thermal, vacuum, and thermal/vacuum chambers
Workforce	311 civil servants and 232 support contractors
Reviews Performed	Capability Leadership Review, July 2015

Actions Taken

As of October 2016, no formal Agency decisions have been made in relation to this capability area.

[37] The assets, facilities, and workforce numbers were provided by NASA. According to Agency officials, some of the information may be double counted across capability areas.

[38] The excluded capabilities are Cryogenics, Instrument & Sensors, Systems Engineering, Autonomous Systems, Aeronautics Research, Astrophysics, Heliophysics, and Planetary.

AEROSCIENCES

The Aerosciences capability captures research and support to human spacecraft designs and missions for all phases of flight, including ascent, entry, and missions outside the atmosphere. NASA uses wind tunnels like the one pictured below to conduct research and testing.

Aerial view of a wind tunnel at Ames. Source: NASA.

Participating Centers	Ames, Armstrong, Glenn, Goddard, Johnson, JPL, Kennedy, Langley, Marshall, and Stennis
Assets or Facilities	16 wind tunnels, as well as several testing facilities such as Glenn's Propulsion Systems Laboratory
Workforce	678 civil servants and 225 support contractors
Reviews Performed	Capability Leadership Review, July 2015

Actions Taken

In August 2016, the Mission Support Council decided to reactivate the Unitary Plan Wind Tunnel at Langley while the Agency continues to search for a viable replacement. As of October 2016, the Agency was working to implement the decision.

AVIONICS

The Avionics capability encompasses flight hardware, related ground support elements, and associated technologies used on aircraft, spacecraft, extra-terrestrial systems, and space launch vehicles. Avionics are an integral part of any spacecraft or science instrument, enabling command and control during flight operations.

Avionics testing of Space Launch System components at Marshall. Source: NASA.

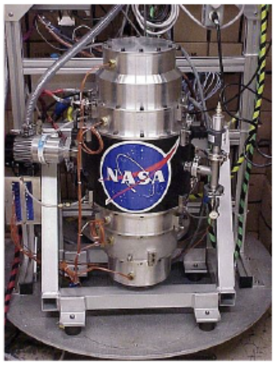
Participating Centers	Ames, Armstrong, Glenn, Goddard, Johnson, JPL, Kennedy, Langley, and Marshall
Assets or Facilities	Three laboratories – two at Goddard and one at JPL
Workforce	1,542 civil servants and 615 support contractors
Reviews Performed	Capability Leadership Review, July 2015

Actions Taken

In November 2015, the Executive Council decided to consolidate electrical, electronic, and electromechanical parts expertise throughout NASA. As of October 2016, the Agency was working to implement the decision.

ELECTRICAL POWER

NASA's Electrical Power capability enables research, development, and implementation of electric power systems for space, near-space, and aeronautics applications. The capability also includes energy storage systems such as the G2 flywheel shown below.



NASA G2 flywheel module used to store rotational energy for use by spacecraft. Source: NASA.

Participating Centers	Ames, Glenn, Goddard, Johnson, JPL, Kennedy, Langley, and Marshall
Assets or Facilities	No dedicated facilities; however, laboratories and other assets are located within other facilities
Workforce	351 civil servants and 122 support contractors
Reviews Performed	Capability Leadership Review, July 2015

Actions Taken

In November 2015, the Executive Council decided to rely on industry for lithium ion battery cells, formalize an agreement for battery cell testing, and address shifts in Agency workforce resulting from these decisions. As of June 2016, the Agency has implemented decisions to rely on industry for lithium ion batteries and formalized an agreement for battery cell testing. As of October 2016, the Agency is working to address the resulting workforce shifts.

FLIGHT MECHANICS

The Flight Mechanics capability encompasses the analysis, prediction, measurement, and test of vehicle dynamics and performance during a maneuver, mission phase, or overall mission. For example, the AirSTAR shown below at Langley conducted research and modeling studies to help pilots understand the impact of loss of control in aircraft.

NASA AirSTAR Flight Research. Source: NASA.

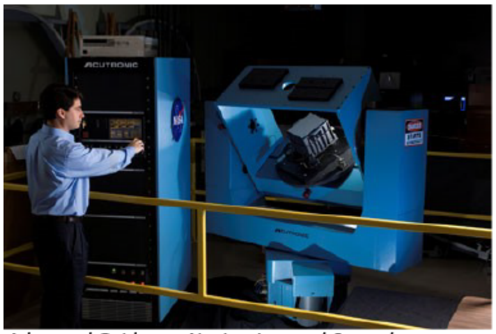
Participating Centers	Ames, Armstrong, Glenn, Goddard, Johnson, JPL, Kennedy, Langley, and Marshall
Assets or Facilities	Numerous assets and facilities, including wind tunnels, test beds, simulators, and specialized software tools
Workforce	482 civil servants and 280 support contractors
Reviews Performed	Capability Leadership Review, July 2015

Actions Taken

In November 2015, the Executive Council directed the Langley Center Director to consolidate Flight Mechanics Facilities at the Center. As of October 2016, the Agency was working to implement the decision.

GUIDANCE, NAVIGATION, AND CONTROL

The Guidance, Navigation, and Control capability encompasses activities related to guiding and controlling a vehicle and its critical subsystems. NASA missions use guidance, navigation, and control for robotic space systems, science, air traffic management, and air vehicle performance.



Advanced Guidance, Navigation, and Control Development Laboratory. Source: NASA.

Participating Centers	Ames, Armstrong, Glenn, Goddard, Johnson, JPL, Kennedy, Langley, and Marshall
Assets or Facilities	59 facilities including laboratories and simulators
Workforce	514 civil servants and 353 support contractors
Reviews Performed	Capability Leadership Review, July 2015

Actions Taken

As of October 2016, no formal Agency decisions have been made in relation to this capability area.

HUMAN FACTORS

The Human Factors capability encompasses the study, analysis, design, and evaluation of human-system interfaces and human organizations as they impact and are impacted by system design across missions. For example, as part of the Commercial Crew Program NASA astronauts are using training simulators to simulate all phases of a mission and practice scenarios ranging from normal operations to emergencies.

Boeing CST-100 Commercial Crew Vehicle Crew-Part Task Trainer. Source: NASA.

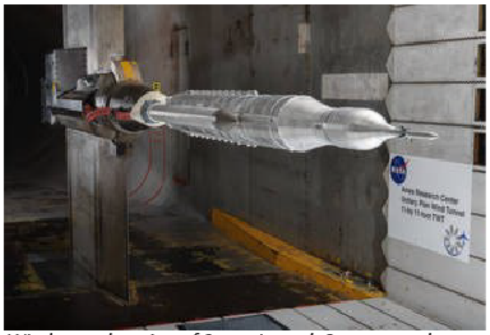
Participating Centers	Ames, Johnson, JPL, Kennedy, Langley, and Marshall
Assets or Facilities	Four dedicated facilities, including a flight simulator facility at Langley as well as a human-rated 20g centrifuge, research facility, and vertical motion simulator at Ames
Workforce	127 civil servants and 131 support contractors
Reviews Performed	TCAT Review, August 2014 Capability Leadership Review, July 2015

Actions Taken

In September 2014, the Mission Support Council established capability leadership for Human Factors. This decision was implemented in July 2015.

LOADS AND DYNAMICS

The Loads and Dynamics capability is a specialty branch of Structural and Mechanical Engineering involving examination of how structures respond to dynamic forces like wind and propulsion. For instance, wind tunnel testing will be used to enhance the design and stability of the Space Launch System.



Wind tunnel testing of Space Launch System mockup at Ames. Source: NASA.

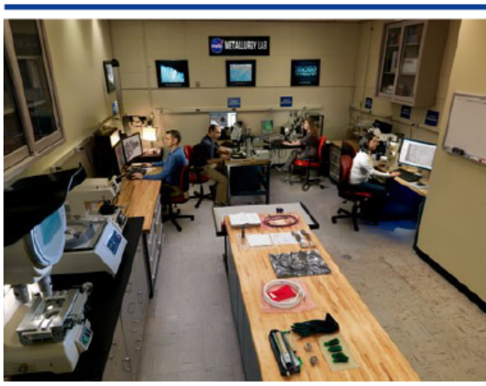
Participating Centers	Ames, Armstrong, Glenn, Goddard, Johnson, JPL, Kennedy, Langley, and Marshall
Assets or Facilities	36 facilities and numerous assets for testing, including vibration, shock, and acoustic testing facilities
Workforce	284 civil servants and 180 support contractors
Reviews Performed	Capability Leadership Review, July 2015

Actions Taken

As of October 2016, no formal Agency decisions have been made in relation to this capability area.

MATERIALS

The Materials capability encompasses metals, ceramics, polymers, and composites used on NASA mission vehicles. NASA conducts both engineering and research activities within this capability area. For example, the Johnson materials research laboratory shown below tests material properties and develops advanced materials.



Materials research laboratory at Johnson. Source: NASA.

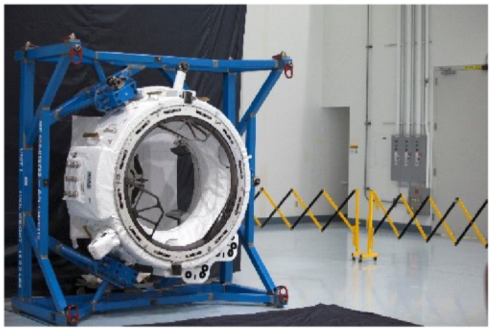
Participating Centers	Armstrong, Ames, Glenn, Goddard, Johnson, JPL, Kennedy, Langley, Marshall, Stennis, and White Sands
Assets or Facilities	Numerous assets, including propellant testing facilities and prototype laboratories
Workforce	497 civil servants and 348 support contractors
Reviews Performed	Capability Leadership Review, June 2015

Actions Taken

In November 2015, the Executive Council decided to consolidate Material Compatibility, Flammability, and Toxicity Testing at White Sands. As of October 2016, the Agency was working to implement the decision.

MECHANICAL SYSTEMS

The Mechanical Systems capability focuses on NASA's ability to research, develop, procure, design, manufacture, integrate, verify, and support mechanical systems. These systems include gimbals, or pointing platforms, docking mechanisms, and flight control mechanisms. The International Docking Adapter, shown below, is a metallic ring that provides a port for spacecraft transporting astronauts and cargo to the International Space Station.



The International Docking Adapter. Source: NASA.

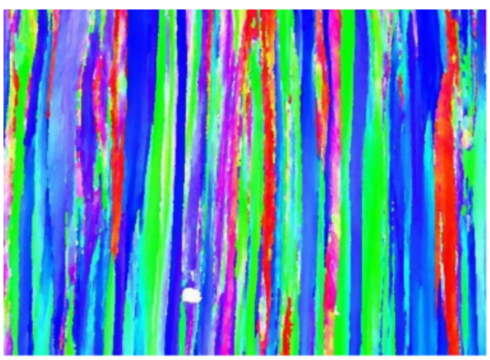
Participating Centers	Ames, Glenn, Goddard, Johnson, JPL, Kennedy, Langley, and Marshall
Assets or Facilities	Assets and facilities were not included in the assessment
Workforce	400 civil servants and 215 support contractors
Reviews Performed	Capability Leadership Review, July 2015

Actions Taken

As of October 2016, no formal Agency decisions have been made in relation to this capability area.

NON-DESTRUCTIVE EVALUATION

The Non-Destructive Evaluation capability supports the process of inspecting, testing, or evaluating materials, components, or assemblies without destroying the serviceability of the part or system. The capability also includes structural health monitoring, which uses sensors within a material or structure to identify flaws. The false color composite, shown below, was created by an electron microscope to detect material defects.



False color composite from electron microscope survey of a Space Launch System component. Source: NASA.

Participating Centers	Ames, Armstrong, Glenn, Goddard, Johnson, Kennedy, Langley, Marshall, and Stennis
Assets or Facilities	Several facilities and portable test assets, including shielded rooms for x-ray devices, as well portable ultrasound devices
Workforce	58 civil servants and 88 support contractors
Reviews Performed	Capability Leadership Review, July 2015

Actions Taken

As of October 2016, no formal Agency decisions have been made in relation to this capability area.

PASSIVE THERMAL

The Passive Thermal capability refers to NASA's efforts to maintain temperatures in aerospace vehicles, spacecraft, instruments, and payloads using materials and devices rather than by pumping fluids. For example, following Orion's first flight test, the Program made changes to the vehicle's heat shield based upon identified weaknesses and cracking.

Orion heat shield from Exploration Flight Test-1. Source: NASA.

Participating Centers	Ames, Armstrong, Glenn, Goddard, Johnson, JPL, Kennedy, Langley, and Marshall
Assets or Facilities	142 facilities
Workforce	293 civil servants and 271 support contractors
Reviews Performed	Capability Leadership Review, July 2015

Actions Taken

As of October 2016, no formal Agency decisions have been made in relation to this capability area.

PROPULSION

The Propulsion capability encompasses designing, developing, testing, evaluating, and operating chemical, nuclear thermal, electric, advanced, and air-breathing propulsion systems for aircraft and spacecraft. The propulsion capability uses test stands, processing facilities, and laboratories such as the A-1 Test Stand shown below.

NASA's A-1 Test Stand at Stennis. Source: NASA.

Participating Centers	Ames, Armstrong, Glenn, Goddard, Johnson, JPL, Kennedy, Langley, Marshall, Stennis, and White Sands
Assets or Facilities	122 assets, including test stands and vehicle and payload processing facilities
Workforce	732 civil servants and 753 support contractors
Reviews Performed	TCAT Review, December 2014 Capability Leadership Review, July 2015

Actions Taken

In January 2015, the Mission Support Council decided to establish a subject matter expert for Nuclear Power and Propulsion and develop an agreement with the Department of Energy on nuclear systems. As of October 2016, these decisions have been implemented. In November 2015, the Executive Council made the following additional recommendations: (1) develop an implementation strategy to address duplication within chemical propulsion, electric propulsion, green propulsion, and Thrust Vector Control activities and (2) consolidate propulsion test facilities at Glenn and Marshall. As of October 2016, implementation is ongoing.

SOFTWARE

The Software capability encompasses the procedures, design considerations, activities, and tasks used to acquire, develop, assure, and maintain software created or acquired for Agency programs. As of 2015, NASA was one of the 100 largest developers and procurers of software in the world.

Space Launch System software being debugged. Source: NASA.

Participating Centers	Ames, Armstrong, Glenn, Goddard, Johnson, JPL, Kennedy, Langley, Marshall, and Stennis
Assets or Facilities	No facilities identified, but numerous software and information technology systems
Workforce	1,836 civil servants and 1,312 support contractors
Reviews Performed	Capability Leadership Review, July 2015

Actions Taken

As of October 2016, no formal Agency decisions have been made in relation to this capability area.

STRUCTURES

The Structures capability is divided into aerospace structures, which house flight systems and protect payloads and humans, and ground system structures, which support space flight and institutional programs and projects.

Mars Science Laboratory payload fairing. Source: NASA.

Participating Centers	Ames, Armstrong, Glenn, Goddard, Johnson, JPL, Kennedy, Langley, and Marshall
Assets or Facilities	Several unique testing facilities including wind tunnels, laboratories, loading frames, and a Helicopter Hover Facility
Workforce	611 civil servants and 441 support contractors
Reviews Performed	Capability Leadership Review, July 2015

Actions Taken

As of October 2016, no formal Agency decisions have been made in relation to this capability area.

System Capabilities

ENTRY, DESCENT, AND LANDING

The Entry, Descent, and Landing capability encompasses systems and hardware used for slowing down, approaching, connecting, or setting down a vehicle on a body with significant gravity and with or without an atmosphere. For example, drop testing similar to that pictured below was performed at Langley on the Orion crew capsule with crash test dummies inside to understand what the spacecraft and astronauts may experience when landing in the Pacific Ocean upon return from deep-space missions.

Orion drop testing at Langley. Source: NASA.

Participating Centers	Ames, Johnson, JPL, Langley, and Marshall
Assets or Facilities	Several assets, including arc-jets, ballistic ranges, shock tube testing, and wind tunnels
Workforce	558 civil servants and 213 support contractors
Reviews Performed	TCAT Review, January 2015 Capability Leadership Review, July 2015

Actions Taken

As of October 2016, no formal Agency decisions have been made in relation to this capability area.

IN-SITU RESOURCE UTILIZATION

The In-Situ Resource Utilization capability encompasses any hardware or operation that utilizes "in-situ" resources at the exploration site to create products and services for robotic and human exploration. For instance, the Regolith and Environmental Science and Oxygen and Lunar Volatiles Extraction Rover shown below is designed to demonstrate the extraction of resources such as hydrogen, oxygen, and water from the lunar surface.

Regolith and Environment Science and Oxygen and Lunar Volatiles Extraction Rover. Source: NASA.

Participating Centers	Ames, Glenn, Goddard, Johnson, JPL, Kennedy, Langley, and Marshall
Assets or Facilities	Several assets, including dedicated vacuum chambers, in-situ/soil mechanics testing facilities, and multiple "rock yards" for hardware testing
Workforce	116 civil servants and 26 support contractors
Reviews Performed	Capability Leadership Review, July 2015

Actions Taken

As of October 2016, no formal Agency decisions have been made in relation to this capability area.

RENDEZVOUS AND CAPTURE

The Rendezvous and Capture capability encompasses operations used to slow the approach of a vehicle, connect to an object or set down on a surface, bring a spacecraft and another space-based object together, or mate two spacecraft or a spacecraft and a space-based object. NASA has utilized the Rendezvous and Capture capability since the beginning of human spaceflight with the Gemini Program and continues today with the International Space Station.

Orbital ATK Cygnus cargo vehicle docking at the International Space Station. Source: NASA.

Participating Centers	Ames, Glenn, Goddard, Johnson, JPL, Langley, and Marshall
Assets or Facilities	No assets or facilities identified
Workforce	282 civil servants and 555 support contractors
Reviews Performed	TCAT review, February 2015 Capability Leadership, July 2015

Actions Taken

As of October 2016, no formal Agency decisions have been made in relation to this capability area.

Research Capabilities

EARTH SCIENCE

The Earth Science capability focuses on research and analysis to advance understanding of the Earth as a system and its response to natural or human-induced changes and improve prediction of climate, weather, and natural hazards forecasting. Data Analysis and Archive Centers, such as the one pictured below, are used to process, archive, document, and disseminate Earth science data.

Data Analysis and Archive Center at Goddard Source: NASA.

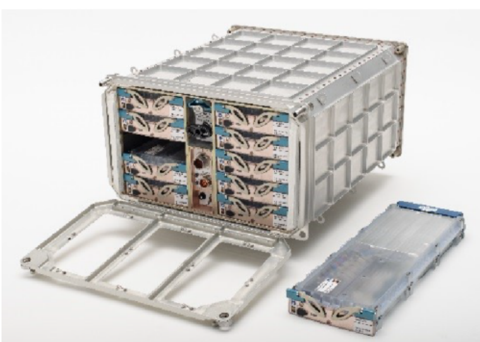
Participating Centers	Ames, Goddard, Johnson, JPL, Kennedy, Langley, Marshall, and Stennis
Assets or Facilities	Several Data Analysis and Archive Centers
Workforce	566 civil servants and 959 support contractors
Reviews Performed	TCAT Review, April 2014 Capability Leadership Review, September 2015

Actions Taken

In July 2014, the Mission Support Council decided to establish a review of the Earth Science data information systems and also to establish capability leadership for Earth Science research and analysis. As of September 2015, both decisions have been implemented.

LIFE SCIENCES

The Life Sciences capability focuses on research capabilities within Astrobiology, Crew Health and Safety, Human Research, Planetary Protection, and Space Biology. One example of research related to Life Sciences is the bioculture system shown below, a cell biology research platform supporting short- and long-duration studies involving the culture of living cells, microbes, and tissues aboard the International Space Station.



A bioculture system to be used aboard the International Space Station. Source: NASA.

Participating Centers	Ames, Glenn, Goddard, Johnson, JPL, Kennedy, and Langley
Assets or Facilities	Several facilities, including an animal care unit at Kennedy
Workforce	83 civil servants and 220 support contractors
Reviews Performed	TCAT Review, July 2014 Capability Leadership Review, September 2015

Actions Taken

In July 2014, the Mission Support Council decided to continue with plans to construct life sciences buildings at Ames and Johnson and a new animal care facility at Kennedy. Additionally, in May 2016, the Mission Support Council decided to increase the number of civil servants for Life Sciences research at Ames. As of October 2016, construction is ongoing and the Agency is working to implement the workforce decision.

Service Capabilities

AIRCRAFT OPERATIONS

The Aircraft Operations capability operates aircraft and unmanned aerial systems (drones), integrates and tests complex experiments in aircraft, and conducts required training and logistics flights. An example of the latter function is the T-38, pictured below, used by NASA astronauts for flight readiness training.


T-38 aircraft operated out of Johnson. Source: NASA.

Participating Centers	Ames, Armstrong, Glenn, Goddard, Kennedy, Johnson, and Langley
Assets or Facilities	153 Total Aircraft, including 63 active aircraft and 2 active unmanned aircraft systems
Workforce	148 civil servants[a]
Reviews Performed	TCAT Review, June 2014 Capability Leadership Review, September 2015

Actions Taken

In June 2014, the Mission Support Council decided to establish a review of the T-38 inventory, as well as establish capability leadership for Aircraft Operations. Johnson completed the T-38 review in August 2014, and the capability leadership review was presented to the APMC in July 2015.

[a] The capability area did not provide a breakdown of support contractors.

ENVIRONMENTS TESTING

The Environments Testing capability encompasses testing to support NASA space flight systems in physical environments during launch and in operation, entry, descent, and landing, and simulates the conditions under which a component or system is expected to perform. Tests include vacuum testing, thermal testing, vibration testing, acoustic testing, weather testing, and pressure testing.


James Webb Space Telescope component undergoing thermal vacuum testing at Goddard. Source: NASA.

Participating Centers	Ames, Armstrong, Glenn, Goddard, Johnson, JPL, Kennedy, Langley, Marshall, and Stennis
Assets or Facilities	Over 200 facilities and 250 asset types[a]
Workforce	1,400 civil servants and support contractors
Reviews Performed	TCAT Review, December 2014

Actions Taken

In February 2015, the Mission Support Council decided to establish a review of the Space Environments Testing Portfolio. This review was completed in September 2015.

[a] As this assessment preceded the space environments review, there may be double counting of workforce and assets or facilities.

MISSION OPERATIONS

The Mission Operations capability includes the operations phase of spacecraft and air vehicles, as well as the operation of ground or flight hardware, software systems, and supporting facilities and personnel. The capability includes all technical aspects of mission execution from the point after liftoff/takeoff through all phases of mission flight/ground activity in all operational disciplines until mission completion. Mission Control at Johnson, shown below, has served missions from Apollo to the International Space Station

Mission Control Center at Johnson Source: NASA.

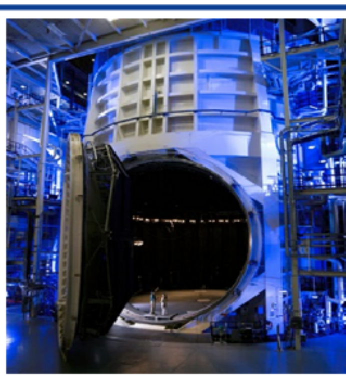
Participating Centers	Ames, Armstrong, Glenn, Goddard, Johnson, JPL, Kennedy, Langley, and Marshall
Assets or Facilities	Numerous assets, including mission operations and science payload operations centers
Workforce	1,870 civil servants and 4,860 contractors
Reviews Performed	TCAT Review, August 2014 Capability Leadership Review, September 2015

Actions Taken

In October 2014, the Mission Support Council decided to appoint a leader to review management of Mission Operations. This decision was implemented in September 2015.

SPACE ENVIRONMENTS TESTING

The Space Environments Testing capability refers to assets NASA utilizes for simulating conditions a component or system is expected to experience when in operation. The largest test types within the capability are thermal, vacuum, and thermal-vacuum chambers such as Johnson's Chamber A shown below.



Johnson's Chamber A thermal-vacuum chamber. Source: NASA.

Participating Centers	Ames, Armstrong, Glenn, Goddard, Johnson, JPL, Kennedy, Langley, Marshall, and Stennis
Assets or Facilities	1,371 assets including vacuum, thermal, and thermal-vacuum chambers
Workforce	126 civil servants and 270 support contractors
Reviews Performed	TCAT Review, December 2014 Capability Leadership Review, September 2015

Actions Taken

In September 2015, the Mission Support Council decided to divest of 20 assets, mothball 6 assets, and perform futher analysis; in November 2015, develop a centralized management model; in March 2016, divest 1 asset; and in May 2016, refer other assets to capability leadership teams for further study.

NOTE: The Space Environments Testing capability information derived from the Environments Testing Capability review, which may result in double counting of facilities and workforce.

APPENDIX C: MANAGEMENT'S COMMENTS

National Aeronautics and
Space Administration
Office of the Administrator
Washington, DC 20546-0001

March 16, 2017

TO: Assistant Inspector General for Audits

FROM: Acting Administrator

SUBJECT: Agency Response to OIG Draft Report "NASA's Efforts to Rightsize Its Workforce, Facilities, and Other Supporting Assets" (A-16-004-00)

NASA appreciates the opportunity to review and comment on the Office of Inspector General (OIG) draft report entitled "NASA's Efforts to Rightsize Its Workforce, Facilities, and Other Supporting Assets" (A-16-004-00), dated February 22, 2017.

In the draft report, the OIG makes four recommendations addressed to the Acting Administrator intended to ensure NASA's efforts to evaluate technical capabilities are institutionalized and sustained over time.

Specifically the OIG recommends the following:

Recommendation 1: Create standardized guidance for performing annual capability assessments that considers, at a minimum, the appropriate time and resources for performing the assessments and the required data, analyses, and expected goals or results.

Management's Response: NASA concurs with this recommendation in that the Capability Leadership Model (CLM) should establish standard guidance for performing capability assessments. As of January 2017, the Office of Chief Engineer has outlined such guidance for the discipline capabilities under their purview, as well as initiated a three-year cadence for assessments rather than an annual assessment by all 19 disciplines. Similar guidance and appropriate schedule cycles will be established for the additional capability categories, including systems, research, and services.

Estimated Completion Date: September 30, 2017

Recommendation 2: Evaluate Capabilities Leadership Model (CLM) assessments and teams to better ensure independence.

Management's Response: NASA concurs with this recommendation in that the CLM should include a level of independence. Ensuring an independent perspective could include external reviews of NASA capability assessments, as well as contributions by potential team memberships. Evaluating the CLM to ensure independence may result in different considerations and approaches based on the type of capability leadership team.

Estimated Completion Date: September 30, 2018

Recommendation 3: Develop and institute training, communications, or other measures to ensure capability assessments are complete, thorough, and include expected goals and results.

Management's Response: NASA concurs with this recommendation in that the CLM should establish some level of training and communications with the intent of improving the capability assessment products. The elements noted in Recommendation 3 are best integrated with the standard guidance noted in Recommendation 1, particularly the establishment of expected goals and results. Furthermore, the issuance of the guidance would be part of a communications strategy to enable consistency across the capability leadership teams.

Estimated Completion Date: September 30, 2017

Recommendation 4: Revise the CLM decision process to include implementation timeframes for dispositioning agreed upon actions.

Management's Response: NASA concurs with this recommendation in that the CLM decision process should include implementation timeframes for dispositioning agreed upon actions. Such implementation guidance would come from the appropriate governing council making the specific capability decision. As with all NASA governing councils, at the Agency level, a decision memo would be issued to capture the expectations for implementation timeframes.

Estimated Completion Date: December 31, 2017

We have reviewed the draft report for information that should not be publicly released. As a result of this review, we have not identified any information that should not be publicly released.

Once again, thank you for the opportunity to review and comment on the subject draft report. If you have any questions or require additional information regarding this response, please contact Lisa Guerra on (202) 358-0741.

Robert M. Lightfoot, Jr.
Administrator (Acting)

cc:
Office of the Chief Engineer/Mr. Roe

Appendix D: Report Distribution

National Aeronautics and Space Administration

Acting Administrator
Acting Deputy Administrator
Associate Administrator
    Deputy Associate Administrator
Acting Chief of Staff
Associate Administrator, Aeronautics Research
Associate Administrator, Human Exploration and Operations
Associate Administrator, Mission Support
Associate Administrator, Science
Associate Administrator, Space Technology
Chief Engineer
Director, Ames Research Center
Director, Armstrong Flight Research Center
Director, Glenn Research Center
Director, Goddard Space Flight Center
Director, Jet Propulsion Laboratory
Director, Johnson Space Center
Director, Kennedy Space Center
Director, Langley Research Center
Director, Marshall Space Flight Center
Director, Stennis Space Center

Non-NASA Organizations and Individuals

Office of Management and Budget
    Deputy Associate Director, Energy and Space Programs Division

Government Accountability Office
    Director, Office of Acquisition and Sourcing Management

Congressional Committees and Subcommittees, Chairman and Ranking Member

Senate Committee on Appropriations
    Subcommittee on Commerce, Justice, Science, and Related Agencies

Senate Committee on Commerce, Science, and Transportation
    Subcommittee on Space, Science, and Competitiveness

Senate Committee on Homeland Security and Governmental Affairs

House Committee on Appropriations
    Subcommittee on Commerce, Justice, Science, and Related Agencies

House Committee on Oversight and Government Reform
Subcommittee on Government Operations

House Committee on Science, Space, and Technology
Subcommittee on Oversight
Subcommittee on Space

(Assignment No. A-16-004-00)