National Aeronautics and Space Administration

June 2019

ANNUAL AIRCRAFT REPORT
FOR
FISCAL YEAR 2018

Office of Strategic Infrastructure
Aircraft Management Division
NASA Headquarters
300 E Street, SW
Washington, DC 20546

Cover Photo: Armstrong Flight Research Center’s B-200 KingAir aircraft, tail number N801NA, taking off for an eight-hour science flight on March 5, 2018. Located on the center of the aircraft’s fuselage is the DopplerScatt radar instrument, developed by NASA’s Jet Propulsion Laboratory in California.

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I. EXECUTIVE SUMMARY

The accomplishments by the Agency's aviation community during the Fiscal Year (FY) 2018 were too many to describe in detail in this report, but in summary, our aviation professionals managed, flew, and maintained 67 active aircraft, including Langley Research Center's newly acquired Gulfstream G-III, totaling 8,320.2 flight hours and 4,586 sorties. With two of the active aircraft placed into inactive status, NASA ended the year with 65 active aircraft in its inventory. NASA's aviation organizations achieved their numerous accomplishments while operating their aircraft safely, ending the year without any fatalities or National Transportation Safety Board (NTSB) reportable mishaps. While the Agency's aircraft operations did incur five Class C and six Class D aircraft mishaps below NTSB's reporting threshold in FY 2018, all but two were ground incidents that spoke to the need for renewed diligence in ground safety. Causal factors of the two flight mishaps were investigated and mitigation measures are either in place or being implemented.

The reported total aircraft costs of $161.2M for FY 2018 fell by 5.3%, or $9.0M, from the prior year. This operational cost decrease came entirely as a result of reduced Science missions at Armstrong Flight Research Center and Johnson Space Center, but offset somewhat by 30% higher costs at Langley Research Center and Goddard Space Flight Center's Wallops Flight Facility. NASA's aircraft costs during the last decade peaked in FY 2016 mainly as a result of aircraft acquisitions at Johnson Space Center and Armstrong Flight Research Center. Without these one-time recapitalization expenditures, compounded by declining Science flight requirements, the Agency's aircraft operational costs declined in FY 2017 and FY 2018. NASA also utilized Commercial Aviation Services (CAS) where appropriate, and included in the total FY 2018 aircraft costs was $5.0M worth of flight services provided by commercial vendors. However, the use of CAS also brought a significant burden of safety oversight, which the Agency's aviation community proactively addressed.

Unmanned Aircraft Systems (UAS) also proliferated across the Agency. It was only in FY 2007 when the then Dryden Flight Research Center (DFRC) first began to operate the Ikhana UAS, the sole reported UAS in the Agency at the time. In the short span of ten years, the Agency's reported inventory of all categories of UAS had grown to over 250 by the end of FY 2018. These UAS were operated across all NASA centers, with the exception of the Glenn Research Center. Most of NASA's 250+ UAS were very small, weighed much less than 55 lbs, with top speeds well below 70 knots. In fact, NASA only operated three large UAS that met the Federal Aircraft requirement for reporting to the General Services Administration (GSA). NASA's UAS, large and small, were operated primarily for Science and Aeronautics Research. However, their uses are rapidly expanding to all functional areas within the Agency, such as structural corrosion inspection and public affairs videography. This proliferation of UAS across NASA, in terms of both their quantity and the variety of missions they serve, has brought about unique challenges in their operational oversight and asset management. The Aircraft Management Division (AMD) in the Office of Strategic Infrastructure (OSI) has actively coordinated with the Inter-Center Aircraft Operations Panel (IAOP) to not only implement policy for safe operations of NASA's UAS, but also to address recommendations from the 2017 Office of Inspector General (OIG) audit report, Report No. IG-17-025, regarding NASA's UAS property oversight.

In FY 2018, NASA's aircraft and their operators enabled the Agency to retrieve International Space Station astronauts (ISS) directly from Kazakhstan after each Soyuz landing, conduct major international Earth Science campaigns, map shrinking Arctic and Antarctic glaciers, perform airborne infrared observations of the stars in the Southern Hemisphere, and develop new Aeronautics technologies to make future aircraft safer and more efficient. NASA's research aircraft measured Kilauea lava effusion, mapped ocean surface currents in the Gulf of Mexico, and sampled greenhouse gases across much of the U.S. NASA's aeronautics research aircraft characterized sonic booms, flight tested technologies to mitigate flutter, and advanced UAS autonomy so that we may one day fly UAS in the thin atmosphere of Mars. NASA's high-performance trainer aircraft helped our astronauts prepare for their missions to the ISS and tackle the nation's future space endeavors. Our aircraft also verified and validated satellite instruments and provided airborne research opportunities to college students aspiring to be future scientists. In short, NASA aircraft operations contributed to every aspect of NASA's missions, supported other federal agencies, and collaborated on joint international research objectives.

The Agency's aircraft operators also continued to be recognized by the federal aviation community. In the last fifteen plus years, NASA garnered 18 Federal Aviation Awards administered by the General Services Administration (GSA). Over the last decade, NASA's flight operations have repeatedly been awarded the Interagency Committee for Aircraft Policy (ICAP) Gold Stand Program Certificate, giving recognition to the Agency's entire community of aviation professionals and the aircraft programs that they manage. In November 2017, NASA's aircraft operations again obtained Level III Safety Management System (SMS) Certification, in accordance with the International Standard for Business Aircraft Operations (IS-BAO), from the International Business Aviation Council (IBAC), becoming the first federal agency to achieve this level of recertification for the entire organization. This SMS certification allowed NASA's aircraft unfettered international operations.

Over NASA's celebrated 60-year history, the Agency's missions have evolved from the country's premier aeronautics research organization, which was previously called the National Advisory Committee for Aeronautics (NACA), to the leading space exploration and scientific research agency that it is today. During these 60 years, NASA's aircraft operations continuously adapted to meet the ever-changing mission demands placed on the Agency in support of earth and space. The pace of change for NASA's aviation community has only accelerated in recent years. Realignment of NASA's aircraft operations to meet the Agency's quickly changing missions began in FY 2005 when Stennis Space Center transferred its sole aircraft to Glenn Research Center. After the disposal of Langley Research Center's Boeing 757 ARIES research aircraft at the end of FY 2006, Langley only operated small aircraft, mostly for Earth Science. With the outsourcing of the Mission Required passenger transport flight services in FY 2008, NASA disposed of all aircraft solely dedicated to passenger flight operations, with only one aircraft reassigned to perform other

Agency missions. Continuing its T-38 reduction plan, Johnson Space Center's T-38 fleet was pared down to 20 aircraft by the end of FY 2013, just two thirds of the 32 T-38 aircraft Johnson Space Center operated in FY 2005. When NASA outsourced the Agency's micro-gravity flight services requirements to Zero Gravity Corporation in 2008, NASA also placed Johnson Space Center's C-9 into permanent storage. After the termination of the Space Shuttle Program, the Agency retired its Shuttle Trainer Aircraft (STA) fleet and its two Shuttle Carrier Aircraft (SCA), sending SCA N905NA to Space Center Houston in the beginning of FY 2013, further illustrating the rapid changes to the Agency's aviation landscape.

Aeronautics research and space operations flight support requirements declined sharply in the first half of last decade, but ameliorated somewhat by the steady rise in Airborne Science research requirements. However, just as the Agency aircraft community began to ramp up in order to support the resumption of human space flight activities in U.S. soil, Science mission requirements have begun to decline. While its flight operations grew in response to rising Science demands, Armstrong Flight Research Center reported reduced operations of its major Science platforms, including the Stratospheric Observatory for Infrared Astronomy (SOFIA) aircraft. With several other major Airborne Science Programs coming to a conclusion, flight operations for Science is expected to further decline in the future.

In the last decade, NASA's aviation community proactively managed its aircraft portfolio to navigate a constantly changing requirements landscape, at the same time overcoming the budget challenges they faced. During that time, NASA reduced its overall active aircraft inventory from 86 in FY 2005 to the 65 by the end of FY 2018, all the while adding new aircraft, such as the Gulfsream G-III at Langley Research Center and the Gulfstream G-V at Johnson Space Center, and disposing of aircraft without mission requirements, such as the Shuttle Carrier Aircraft (SCA) and Shuttle Training Aircraft (STA). To enable missions while containing costs, NASA's aircraft operations shared aircraft, flight crew, and logistic support resources; and implemented the aircraft regionalization initiative. In addition, our aircraft operations took advantage of excess DOD assets to add or replace flight capability and as no-cost parts support, sometimes even with dissimilar aircraft that had similar components or parts.

AMD, as the Aircraft Capability Lead in managing NASA's aircraft, initiated a baseline review of all NASA aircraft, including non-operational aircraft, such as display assets and parts aircraft. Coordination with the General Services Administration (GSA) to dispose of aircraft NASA no longer needed began well before the end of FY 2014, resulting in the Agency disposing 17 non-operational aircraft and returning $2.3M in sales proceeds to NASA's aircraft operations in FY 2015. Continuing the progress already made, NASA's aviation community further disposed of five manned aircraft and over 100 mostly small UAS in FY 2018, demonstrating the community's coordinated response to address the OIG's 2017 audit recommendations.

This report also incorporates the forward-looking Annual Aircraft Requirements Analysis as required by NPR 7900, with inputs from the Aircraft Advisory Committee (AAC) integrated for the first time. The analysis of FY 2019 and out-year aviation requirements reviewed all aircraft mission and program requirements, aircraft use, and associated costs projected over a five-year horizon. The FY 2019 Requirements Analysis verified that all active NASA aircraft were meeting funded requirements that were linked to the Agency's strategic plan. Airborne Science requirements are expected to hold steady over the five-year horizon, but at a much-reduced level of operation in comparison with past years. However, the declining SMD funding trend also reflects the lag in program and project aircraft selection decisions and may not be as dire as the trend seemed to suggest. Human Exploration and Operations Mission Directorate (HEOMD) aircraft requirements, on the other hand, are projected to see some growth in the outyears with new requirements emerging from the Moon to Mars initiative.

The Agency's reprioritization of resources as it transitions from the Space Shuttle Program to Commercial Space is expected to continue to impact NASA's aircraft operations in the next few years. As NASA proceeds through this transition period, the mission enabling capabilities of the Agency's aircraft must be clearly understood and shepherded. NASA's aviation is the world leader in airborne science, aeronautical research, and space program support. It has taken years to establish this capability and it must be carefully managed to ensure the United States continues to lead in these critical mission areas. To this end, NASA's aviation community proactively manages the risks involved in the right-sizing of flight operations in support of developing space programs, changing airborne research requirements, as well as re-energized aeronautics research initiatives that will require flight test and demonstration.

II. INTRODUCTION

NASA's aircraft operations have continuously evolved over the long history of the Agency, from its NACA days of pioneering aeronautics technologies to today's predominantly airborne scientific research and astronaut flight training. This FY 2018 Annual Aircraft Report documents the key accomplishments by NASA's aviation community over the past fiscal year.

This report is prepared in accordance with NPD 7900.4C, the Agency's policy directive on Aircraft Operations Management. The contributions and accomplishments made by NASA's aviation professionals and the diverse aircraft managed, maintained, operated, and supported by them during FY 2018 are summarized in the report. This report also provides a status of NASA's aviation resources and the major changes that took place during the fiscal year.

Excluding the small Unmanned Aircraft Systems (sUAS) that did not meet the Agency's Capital Asset definition, NASA's aircraft in FY 2018 were home-based at seven NASA Centers across the United States and flown throughout the world. Figure 1 below lists the Agency's active aircraft assets that were managed and operated at the various NASA sites as of the end of the fiscal year. NASA's aircraft inventory also included many display, parts, and other non-active aircraft that were held in flyable or non-flyable storage status for future needs, but are too extensive to be detailed here.

NASA Inventory of Active Aircraft
September 30, 2018

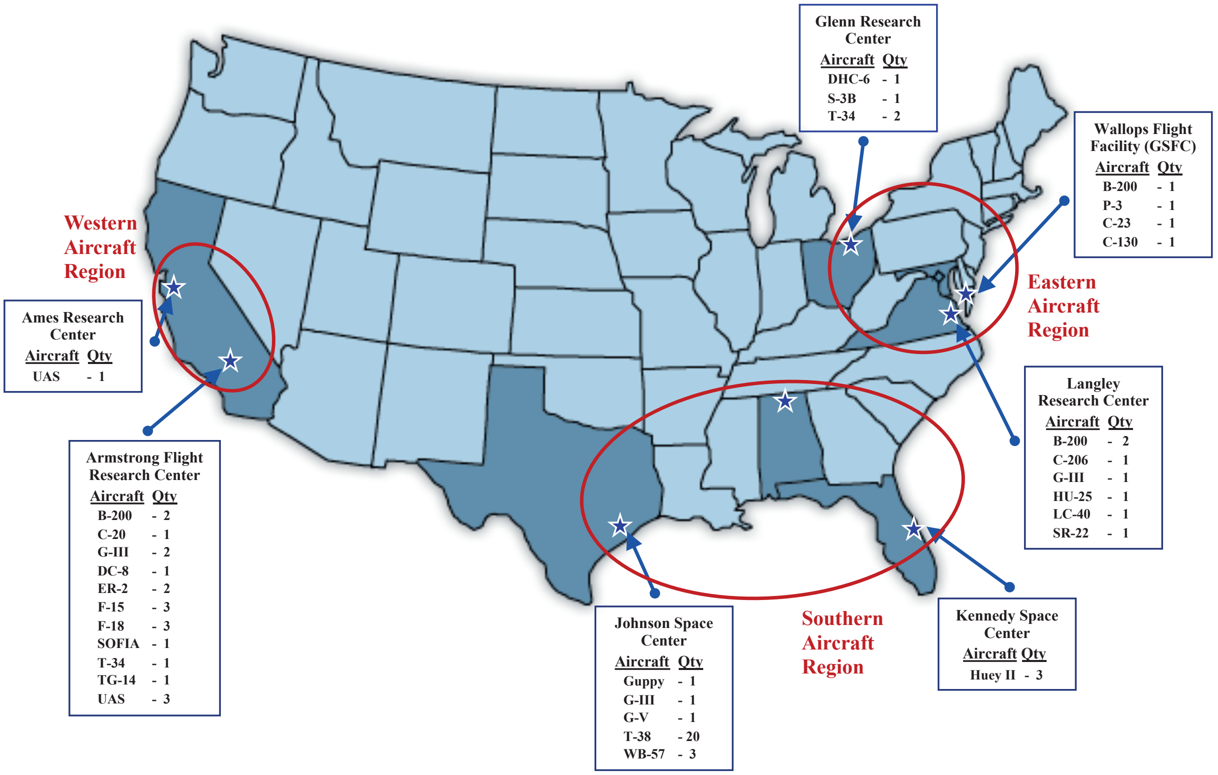

Figure 1 – NASA Aircraft by Location

Implementing the October 2016 Executive Council decision, NASA's aircraft operations were integrated into three regions in FY 2017 – the Eastern Aircraft Region, the Southern Aircraft Region, and the Western Aircraft Region. The aim of the Regional Aircraft Management Model was to increase collaboration, reduce redundancy, and improve aircraft operational efficiency between aircraft centers. The Eastern Aircraft Region consisted of the flight operations at Glenn Research Center, Goddard Space Flight Center's Wallops Flight Facility, and Langley Research Center, with Langley as the regional lead. The Southern Aircraft Region, led by Johnson Space Center, teamed Johnson's flight operations with aircraft operations at Kennedy Space Center, Marshall Space Flight Center, and Stennis Space Center, the last two of which only operated sUAS. The Western Aircraft Region, with Armstrong Flight Research Center as the lead, integrated the UAS operations at Ames Research Center with the much larger aircraft operations at Armstrong. In addition, Armstrong Flight Research Center also provides airworthiness oversight for Jet Propulsion Lab's CAS operations.

Whether in the day-to-day aircraft operation or in the ongoing implementation of the regionalization initiative, it was the people that managed, operated, and maintained the Agency's aircraft that made NASA's flight operations an essential infrastructure capability for the Agency. Although the Aircraft Management Division (AMD) in the Office of Strategic Infrastructure (OSI), established and implemented aircraft operational policy to ensure our flight risks were mitigated, it was the aviation professionals at NASA centers that enabled the accomplishment of the Agency's myriad missions. NASA's aviation professionals included both civil servants and contractors that incorporated an assorted blend of skills, experience, and professional knowledge from civil, military, and astronaut backgrounds. They, and the aircraft they operated, enabled the Agency to achieve its goals and visions for Science, Aeronautics Research, Human Exploration, and Space Technology without any major mishaps in FY 2018.

Mission Directorates and Center Directors were again required by NPR 7900.3C to review aircraft mission and program requirements and associated costs, and project those requirements and costs over five years in an annual report to the Aircraft Management Division. Specifically, OSI requested aircraft funding projections from both the Mission Directorates, as well as Centers with operational aircraft. The goal of the FY 2019 requirements analysis was to ensure that NASA's aircraft continued to be utilized to meet funded requirements that were clearly linked to the Agency's Strategic Plan, and to facilitate strategic resource decision making based on the costs of aircraft ownership. This report also provides the results of the FY 2019 aircraft requirements analysis, as well as a roadmap projection for NASA's small fleet of aircraft.

III. MISSIONS OF NASA AIRCRAFT

NASA's aviation professionals and aircraft provide critical support to the Agency. They enable the Agency to accomplish its stated mission – "*to pioneer the future in space exploration, scientific discovery, and aeronautics research*." NASA's aircraft are generally operated in direct research and development, in support of program execution, and for limited passenger transportation. NASA's aircraft directly and indirectly enable the Agency to meet its mission requirements as laid out in the Agency's Strategic Plans.

SUPPORT OF PROGRAM EXECUTION

NASA's support flight operations enable the accomplishment of NASA's strategic objectives. Such flights include, but are not limited to, astronaut training, safety chase, photo chase, cargo transport, flight crew training, range surveillance, launch security, weather reconnaissance, contingency support, and command and control. By far, most of the Agency's support flight operations are conducted for NASA's myriad space programs. One example is Johnson Space Center's T-38 Space Flight Readiness Training aircraft. NASA and international astronauts train in the T-38 jets to prepare for their missions in space.

Figure 2 – JSC T-38 trainers fly above both Space Shuttle Atlantis and Space Shuttle Endeavour.

Another example of the Agency's support flight operation is Kennedy Space Center's (KSC) small fleet of Huey II helicopters. Kennedy's helicopters, enhanced with night vision goggles (NVGs) and Forward Looking Infrared (FLIR) cameras, protect against threats to both Agency and space partner assets. Additionally, these utility helicopters enable the space center to monitor the health, biodiversity, and impacts on the wildlife refuge within which Kennedy resides.

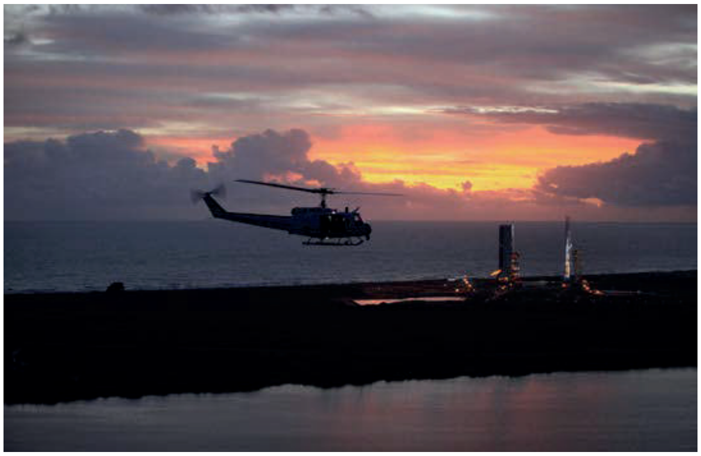

Figure 3 – KSC Huey II helicopter provides security during early morning launch.

DIRECT RESEARCH & DEVELOPMENT OPERATIONS

NASA's R&D flight operations are a means for the Agency's Mission Directorates to conduct research and flight test at various altitudes and atmospheric conditions. In this capacity, NASA's aircraft are flown to advance aeronautics research, to expand human knowledge of Earth and space science, and to support the Vision for Space Exploration. In FY 2015, the Agency's R&D flight operations were flown to advance aeronautics technology, to validate NASA's satellites, to measure changes in the environment, and to study star formations in our galaxy and beyond. At Goddard Space Flight Center's Wallops Flight Facility, its uniquely modified P-3B aircraft was flown to measure polar ice changes from the increased greenhouse gases in the atmosphere.

Figure 4 – As a part of the Operation Ice Bridge (OIB) campaign, GSFC P-3B deployed to Greenland to study the loss of Arctic ice from global warming.

LIMITED PASSENGER TRANSPORTATION

With the decommissioning in FY 2008 of all of what was then called Mission Management Aircraft (MMA), NASA no longer operated aircraft that were flown solely for passenger transport. NASA, however, has five Program Support aircraft that can be used to carry passengers in secondary roles. These five aircraft are authorized to carry passengers in conjunction with their primary training missions or when not otherwise engaged in other support missions. Use of these five aircraft for justified passenger carriage, and supplemented with Commercial Aircraft Support (CAS) when needed, provide a means of economical and rapid transportation for NASA's technical and professional personnel to meet NASA's mission requirements.

Figure 5 – NASA 7, a King Air B-200 aircraft, primarily performs pilot proficiency training missions, but can also be operated for secondary passenger transport roles.

IV. NASA'S AVIATION PROFESSIONALS

It is NASA's aircraft pilots, maintainers, engineers, and other support personnel; both civil service and contractor personnel; that coordinate the daily flight and maintenance activities, integrate R&D payloads on to the Agency's aircraft, manage the finances of the flight operations, ensure NASA's aircraft are safe to operate, and execute the Agency's unique missions. Besides being known for advanced scientific research and space exploration, NASA is also one of only a few federal agencies with the technical capability and the authority to certify the airworthiness of NASA-owned aircraft, as well as contracted aircraft. This flight certification authority recognizes the Agency's expertise in aircraft engineering, modeling and simulation, flight-testing, quality assurance, aviation safety; as well as the higher standards that NASA's aviation community holds itself to.

The Agency's aviation professionals have long been recognized for their achievements in federal aviation. In the last eighteen years, NASA won eighteen Federal Aviation Awards administered by the General Services Administration (GSA). This long history of recognition began with Johnson Space Center's aircraft operations being selected as the Federal Aviation Program of the Year for Calendar Year (CY) 2001 and Mr. Robert Naughton, Johnson's then chief of flight operations, being named the Federal Aviation Manager of the Year for CY 2003. NASA's aircraft operations have also won multiple GSA Federal Aviation Awards in 2005, 2012, and 2014. Notably for CY 2014, Johnson's aircraft operations won the large program category; Mr. Dan Swint, Johnson's manager for the NASA Aircraft Management Information System (NAMIS), was recognized as the Aviation Professional of the year; and GSA picked aircraft operations at Wallops Flight Facility as the winner of the small program category. More recently in August of 2016, Mr. Jim Smolka, Armstrong Flight Research Center's prior chief of flight operations won GSA's Federal Aviation Professional Award in the Managerial/Official Category for CY 2015.

In addition, GSA in 2007, 2011, 2013, 2015, and then again in 2018 awarded NASA's flight operations the Interagency Committee for Aircraft Policy (ICAP) Gold Standard Program Certificate, giving recognition to the Agency's entire community of aviation professionals and the aircraft programs that they manage. More notably, after becoming the first federal agency to obtain a Level II Safety Management System (SMS) certification in November 2012 from the International Business Aviation Council (IBAC) in accordance with the International Standard for Business Aircraft Operations (IS-BAO), NASA obtained Level III registration from IBAC in November 2014. With the 2014 SMS certification, NASA again led all federal aircraft operations as the first-ever federal agency to reach Level III IS-BAO registration. NASA's aircraft operations were recertified to Level III IBAC SMS standards in November 2017. These IS-BAO certifications by IBAC not only recognized the excellence of NASA's aviation operations and safety programs, but also facilitated NASA's aircraft operations worldwide.

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V. NASA'S AIRCRAFT INVENTORY

As Only NASA Can

Many NASA aircraft are one-of-a-kind research and support aircraft that are often without peers in the world. One example of NASA's unique R&D and Program Support aircraft is Johnson Space Center's WB-57 research aircraft. They are the only three flying WB-57 aircraft remaining in the world and routinely fly a variety of suborbital science missions for the Science Mission Directorate and reimbursable customers. These WB-57s are long-range aircraft that can operate from sea level to altitudes well in excess of 60,000 feet, have an endurance of about 6.5 hours, and can carry up to 6,000 pounds of scientific payload. In addition to flying science missions, the WB-57 aircraft have also flown in support of the launches of the retired Space Shuttles, providing critical film footage for safety analysis.

Figure 6 – JSC WB-57 in flight over the San Jacinto Monument in Texas.

The Stratospheric Observatory for Infrared Astronomy (SOFIA) aircraft, which was reassigned from Ames Research Center to Armstrong Flight Research Center in November 2006, is a Boeing 747 outfitted with the largest telescope ever placed in an aircraft. This one of a kind aircraft completed flight testing and certification at Armstrong Flight Research Center at the end of FY 2010. The SOFIA aircraft, with its 20-ton telescope, flies up to 40,000+ feet with a nine-foot door opened in flight to conduct infrared astronomy missions in the stratosphere. By flying up to 40,000+ feet altitude, the SOFIA aircraft enables infrared observations of the night sky largely unhindered by atmospheric water vapor, 99% of which is concentrated at the lower altitudes.

Figure 7 – SOFIA flight envelope expansion test flights at Armstrong Flight Research Center.

At the Armstrong Flight Research Center, two ER-2 aircraft perform a variety of high-altitude science missions over various parts of the world. They are used for earth science and atmospheric sensor research and development, satellite calibration and data validation. Most missions for the ER-2 last about six hours with ranges of approximately 2,200 nautical miles. These aircraft typically fly at altitudes above 65,000 feet. In November 1998, NASA's ER-2 reached an altitude of 68,700 feet and set a world record for medium weight aircraft.

Figure 8 – AFRC ER-2 lifts off for a CALIPSO / CloudSat validation instrument checkout flight.

NASA also operates Unmanned Aircraft Systems (UAS), referred to by many as drones, such as the SIERRA UAS that Ames Research Center has been preparing for scientific research. UAS, many of them Commercial-off-the-Shelf (COTS) assets, are also employed by NASA for many aspects of Agency functional support, such as aerial inspection of infrastructure and aerial photography. By quantity, NASA operates mostly small UAS (sUAS) that are below the required reporting threshold established by NPR 7900. However, even the sUAS are defined by the Federal Aviation Administration (FAA) as aircraft, and, as such, their acquisition, operation, and disposition are subject to federal and NASA management oversight rules and regulations.

Figure 9 – ARC SIERRA preparing to undergo flight envelope expansion flight tests.

FY 2018 Aircraft Inventory Changes

In the Eastern Aircraft Region, confronted with reduced Airborne Science Program requirements, Goddard Space Flight Center's Wallops Flight Facility placed one of its two operational C-130 aircraft into storage. On the other hand, Langley Research Center (LaRC) in early FY 2018 acquired and began missionizing a DOD excess Gulfstream G-III aircraft as a direct operational replacement to the center's HU-25 Falcon aircraft to better meet future airborne science missions. Since Johnson Space Center and Armstrong Flight Research Center already operated Gulfstream G-III aircraft, Langley's transition from the HU-25 to the G-III also created opportunities for the three centers to collaborate in their aircraft operations.

In the Western Aircraft Region, Armstrong Flight Research Center put away its Ikhana UAS at the end of FY 2018 as NASA no longer had mission requirements for the unmanned aircraft. At the same time, Armstrong also activated a Global Hawk UAS that had been used as parts for planned reimbursable work in FY 2019. In contrast to the other two regions, the Southern Aircraft Region did not report any aircraft inventory changes.

When the Mission Support Council designating the Aircraft Management Division (AMD) as NASA's Aircraft Capability Leader in 2014, AMD initiated a baseline review of all NASA aircraft, including non-operational display assets and parts aircraft. Along with the newly established Aircraft Advisory Committee (AAC), AMD implemented a continuously updated multi-year roadmap for the acquisition and disposition of the Agency's aircraft. The initial emphasis of the roadmap had been to eliminate aircraft that were no longer needed by NASA and to take advantage of any exchange/sale opportunities to return the residual values of idle aircraft back into NASA's aircraft operations. In recent years, AMD also emphasized the disposal of unneeded Unmanned Aircraft Systems (UAS). In summary, NASA transferred five manned aircraft to museums for display and excessed a total of 115 mostly small UAS (sUAS) in FY 2018.

FY 2018 Aircraft Inventory Summary

NASA's aircraft inventory is never static. Unneeded aircraft are put away and new aircraft added to meet ever changing mission sets. NASA operated a total of 67 active aircraft during FY 2018, including Armstrong's activation of an additional Global Hawk UAS and Langley's addition of a Gulfstream G-III. With the deactivation of Armstrong's Ikhana UAS and one of Wallops's C-130 aircraft, NASA ended the fiscal year with 65 active aircraft. The 67 aircraft operated during FY 2018 were markedly less than the 79 operated by NASA in 2008 or the 86 aircraft that the Agency flew in FY 2005. While the overall aircraft inventory trend was negative in the preceding decade, NASA's number of active aircraft at the end of each fiscal year has hovered around 65 for the last six years as shown in Figure 10 below.

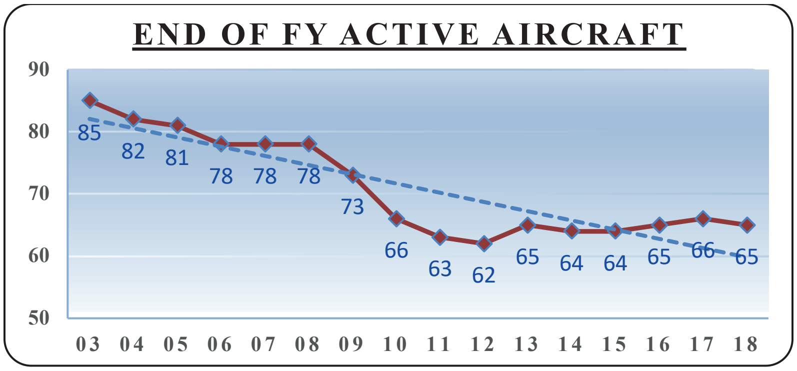


Figure 10 - NASA Aircraft Inventory

In the last fifteen years, NASA has pared its active aircraft fleet by more than 20%. Reductions of the Agency's aircraft initially came as a result of the termination of the Space Shuttle Program. With stabilized Astronaut Corps requirements, Johnson Space Center's T-38 fleet was pared to 20 aircraft by FY 2015, but no additional T-38 cuts were made since. In more recent years, reduced Airborne Science Program requirements have resulted in curtailed operations of manned aircraft at Wallops Flight Facility and unmanned aircraft at Armstrong Flight Research Center.

NASA's operation of small UAS (sUAS) grew rapidly in the last decade for a variety of non-traditional aircraft uses, such as technology research, mishap investigation, facility inspection, and public affair videography. By FY 2017, NASA centers reported slightly over 250 operational and non-operational UAS, with the vast majority of them being sUAS below the Agency's reporting threshold. In the last year, however, new cyber security measures, stronger UAS inventory control procedures, and UAS collaboration across the Agency have actually halted the expansion of NASA's sUAS inventory.

Figure 11 below and Table 1 on the following page provide a Center-by-Center snapshot of the aircraft NASA operated at the end of FY 2018, including reportable UAS. Since the majority of the Agency's aircraft were operated in direct and indirect support of NASA's space programs, it's not surprising to see from Figure 11 and Table 1 that Johnson Space Center still operated most of the Agency's aircraft in terms of quantity. Armstrong Flight Research Center, on the other hand, with its eleven R&D aircraft, operated the bulk of NASA's research fleet.

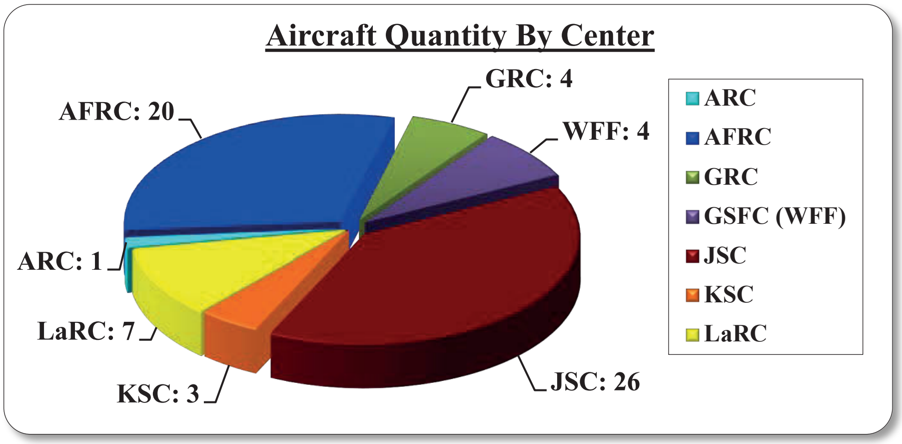


Figure 11 – Quantity of Aircraft at NASA Centers

Not so apparent by the aircraft quantities shown in Figure 11 and Table 1 was that most of NASA's research aircraft were operated for Science missions in FY 2018 and that has been the case for the last decade and more. In fact, close to half of NASA's aircraft fleet either directly or indirectly supported Earth Science or Space Science missions and campaigns in FY 2018. Despite NASA's aeronautics research flight operations having become a small fraction of the Agency's overall aircraft operations in recent years, growing research to integrate UAS into the National Air

Space (NAS) and the renewed interest in flight demonstration of aeronautical technologies have driven the acquisitions of experimental X-plane aircraft, e.g. the X-56 Multi-Use Technology Testbed. While aircraft operations in support of Space programs have stabilized in recent years, reduced Airborne Science Program requirements, as well as increasing reliance on Commercial Aircraft Services (CAS) providers, resulted in the slight reduction of NASA's overall aircraft inventory for NASA in the last fiscal year.

Table 1 – NASA's Active Aircraft and Quantity by Location

ARC		AFRC		GRC		GSFC (WFF)	
Aircraft	**Qty**	**Aircraft**	**Qty**	**Aircraft**	**Qty**	**Aircraft**	**Qty**
Sierra UAS (Ship #2)	1	B-200	2	DHC-6	1	B-200	1
		DC-8	1	S-3B	1	C-23	1
		ER-2	2	T-34	2	C-130	1
		F-15B/D	3			P-3	1
		F/A-18	3				
		G-III	3				
		Global Hawk UAS	2				
		SOFIA	1				
		T-34	1				
		TG-14	1				
		X-56 UAS	1				

JSC		KSC		LaRC		MSFC	
Aircraft	**Qty**	**Aircraft**	**Qty**	**Aircraft**	**Qty**	**Aircraft**	**Qty**
B-377SG	1	Huey II	3	B-200	2		
G-III	1			Cessna 206	1		
G-V	1			HU-25	1		
T-38	20			G-III	1		
WB-57	3			Lancair LC-40	1		
				SR-22	1		

A complete list of the aircraft, including reportable UAS, that NASA operated during FY 2018, these aircraft's primary missions, and their recorded values are provided in more detail in Appendix 1. Aircraft information sheets, each containing a representative photo and brief aircraft descriptions, for the year-end inventory are provided in Appendix 2.

External Aviation Resources

Inter-Agency Cooperation

While the majority of NASA's flight requirements were met by the Agency's own aviation resources, NASA also frequently relied on aircraft services from other federal agencies for a variety of missions. The US Air Force has been supporting NASA's Orion Spacecraft Program for years and NASA engineers completed final development testing of the Orion Spacecraft's parachute system with a drop test from a US Air Force C-17 aircraft in March 2017. An US Air Force C-17 cargo aircraft transported NASA's InSight spacecraft from Buckley Air Force Base in Denver, Colorado to Vandenberg Air Force Base in California on February 28, 2018. Before that, an US Air Force C-5 aircraft delivered the optical telescope assembly for the James Webb Space Telescope, including its giant segmented mirror and suite of instruments, to Los Angeles International Airport for eventual transport to Northrop Grumman's Redondo Beach, California, facility.

Figure 12 – USAF C-17 delivering NASA InSight spacecraft to Vandenberg Air Force Base.

Commercial Aviation Services

Commercial Aviation Services (CAS), such as chartered aircraft services, was another resource for the Agency to supplement, and in some cases replaced, NASA's own aircraft capabilities. In September 2017, after Hurricane Harvey devastated Houston, Goddard Space Flight Center (GSFC) contracted for emergency charter flight services to transport relief crew for the James Web Telescope Program to Johnson Space Center (JSC) because none of NASA's own passenger-capable aircraft were available for the emergency mission.

Besides Mission Required passenger transportation, NASA also utilized CAS to support its research missions. For example, the Jet Propulsion Lab (JPL), under the oversight of Armstrong Flight Research Center (AFRC) reported over 540 flight hours of airborne research on a number of CAS aircraft in FY 2018. In addition, Goddard Space Flight Center's Wallops Flight Facility oversaw 765.6 flight hours of airborne science research conducted by CAS operators.

While NASA's aircraft were acquired and operated in FY 2018 to fulfill unique Agency missions, CAS allowed the Agency to tap into vast commercial resources as needed. While it was important to maximize the use of NASA's own aircraft, CAS has been, and will always be, indispensable in supplementing NASA's own aircraft capabilities.

VI. CONTRIBUTIONS TO MISSION

In FY 2018, NASA's aircraft operators flew a total of 8,320.2 flight hours and 4,586 sorties in support of the Agency's missions. These numbers do not include external flight support services, such as Commercial Aviation Services (CAS) or the use of US Air Force aircraft. NASA operated its aircraft in FY 2018 almost exclusively for research and development (R&D) and program/project support (PS) missions, with only very few dedicated passenger transport (Pax) flights. As shown in Figures 13 and 14 below, 54% of the flight hours and 76% of the sorties were flown for program/project support and the bulk of these flights were flown in support of NASA's space programs. For example, 67% of the flight hours and 71% of the sorties of the Agency's FY 2018 program/project support operations were astronaut training flights.

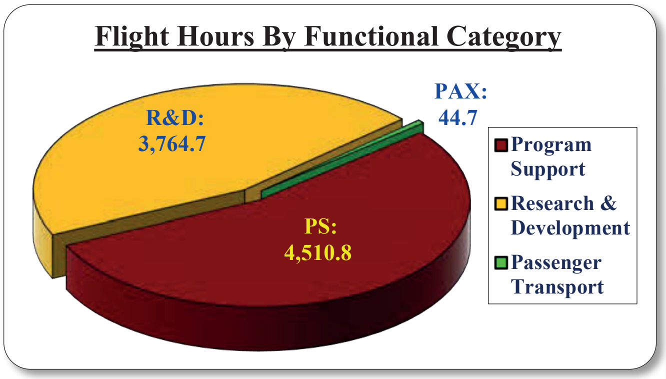
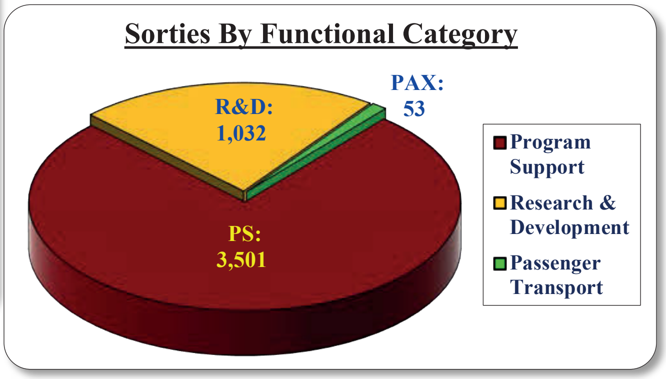


Figure 13 - NASA Aircraft Flight Hours in FY18

Figure 14 - NASA Aircraft Sorties in FY18



As for passenger transportation, our aviation professionals flew a total of 44.7 hours and 53 flights, all of which the primary mission purpose were for pilot proficiency training. We carried 196 passengers and logged over 27,000 passenger-miles in support of NASA's programs during FY 2017. From the two figures above, it is evident that our FY 2018 passenger flights were only a minute fraction of our overall flight operations during the fiscal year. Our passenger flight operations in FY 2018 were less than 3% of the FY 2003 peak when measured in terms of the passengers carried and flights flown. NASA's significantly curtailed passenger flight operation is a testament of the Agency's stringent passenger flight authorization and oversight process.

It is especially important to note that each passenger transport flight in FY 2018, even those that were flown in conjunction with pilot proficiency training, were reviewed and authorized in accordance with strict Office of Management and Budget (OMB) and NASA policy guidelines, meaning that each flight was justified by mission or non-availability of commercial airline flights. Complying with the December 2017 OMB policy memorandum further restricting the use of government-owned, leased, rented, or chartered aircraft for travel, NASA did not conduct any passenger flights that could have been justified based on costs avoidance.

Figures 15 and 16 on the next page provide a breakdown of the Agency's FY 2018 passenger transportation flights by Center. Notably Johnson Space Center only operated its

Gulfstream G-V aircraft for Direct Astronaut Return and Airborne Science missions during the fiscal year and did not conduct any passenger carriage flights. While Goddard Space Flight Center and Armstrong Flight Research Center did transport passengers on their King Air B-200 aircraft, the flights were all short-range regional operations. The agency's passenger flight operations were projected to further decline with the President's more stringent policy on passenger flight authorizations.

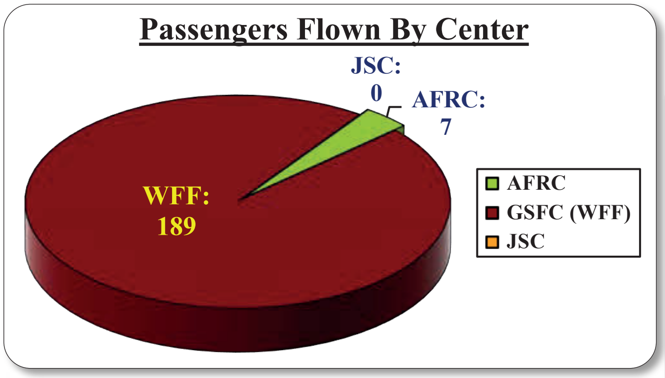


Figure 15 – Total Passengers Flown in FY18

Figure 16 – Total Passenger-Miles Flown in FY18

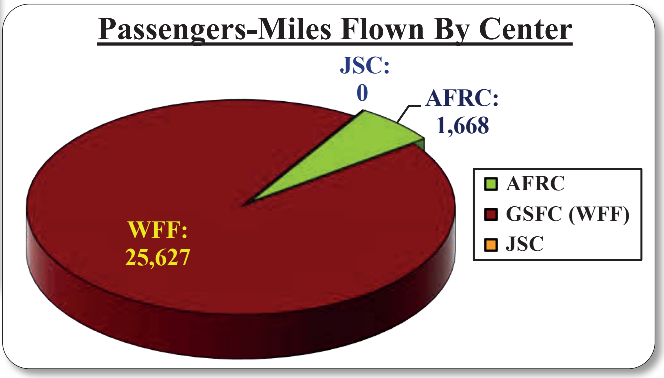


Figure 17 below displays the overall scope of flight operations conducted by the Agency for the past decade, beginning with FY 2008. The figure presents the changes that took place over the last decade in terms of flight hours and sorties flown with NASA's aircraft. Our prior reports discussed a decline in overall Agency aircraft operations from 2003 to 2009, with the decline only halting temporarily in 2005. Over the last ten years, NASA's aircraft operations continued to trend down. While the Agency's flight operations appeared to have stabilized between FY 2014 to FY 2015, compared to the prior year, NASA's FY 2018 aircraft operations fell by another 3.0% in terms of flight hours and essentially a flat trend for flight sorties.

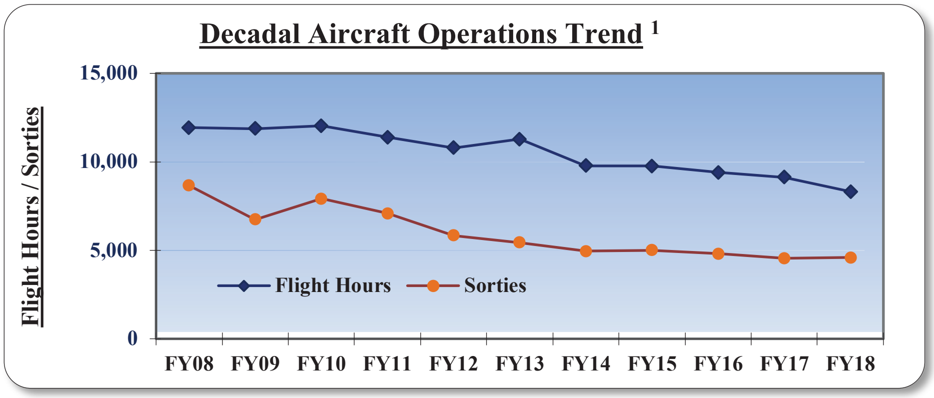


Figure 17 - NASA Aircraft Operations Trend

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[1] Data shows NASA aircraft flight operations only. Flights on aircraft from external sources are not included.

The Agency's flight operations for the past decade are further broken down into research and development (R&D), program/project support (PS), and passenger carriage categories in Figures 18 and 19 below. Figure 18 shows the flight-hour trends and Figure 19, the sortie trends, for the Agency's three aircraft operations categories. These two figures show that, except for program/project support, we have seen a general and steady decline for NASA's overall aircraft operations over the last several years. With renewed national emphasis on space exploration, program/project support flight operations in support of NASA's space operations rebounded in FY 2018. Figures 18 and 19 also clearly show that NASA's passenger flight operations were kept to an absolute minimum during the fiscal year.

NASA's Program Support flight operations had seen significant reductions over much of the last decade, but it appears to have stabilized in the last few years. With increased T-38 astronaut flight training, the Agency's Program Support flight operations rose by 10% over the previous year. In comparison with the prior fiscal year, Johnson Space Center's 2018 T-38 flight operations rebounded by 6.5% in terms of both flight hours and flight sorties. Increased flight operations in the direct return of astronauts from Kazkhstan to Johnson Space Center, as well as higher operational tempo of support flights at Armstrong Flight Research Center and Goddard Space Flight Center's Wallops Flight Facility, have also contributed to the rise in Program Support flight operations.

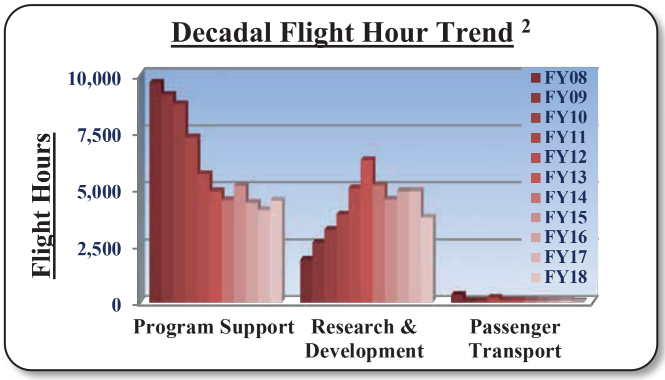
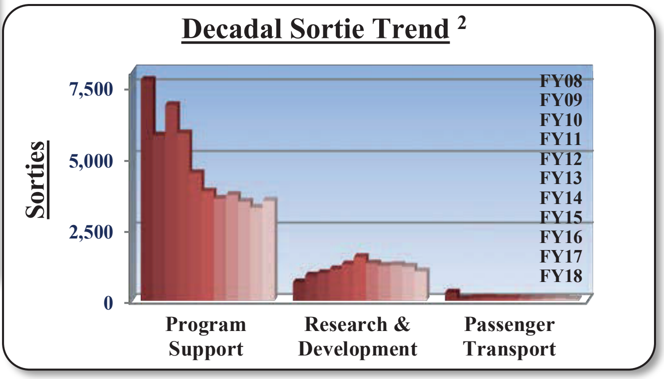


Figure 18 – NASA Flight Operations (Flight Hours) Trend

Figure 19 – NASA Flight Operations (Sorties) Trend



In contrast to the Agency's program/project support flight operations, NASA's R&D flight activities, which had expanded steadily until FY 2013, saw a reversal in fortunes in recent years. NASA's R&D flight operations in FY 2018 declined by more than 20% over the previous fiscal year's performance. This decline in R&D flight operations over the last five years was, by far, the result of decreased demand for airborne Earth Science and Space Science research. In particular, the decreased R&D flight operations reported in FY 2018 came as a result of reduced operations across a broad spectrum of Airborne Science platforms at Armstrong Flight Research Center,

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[2] Data shows NASA aircraft flight operations only. Flights on aircraft from external sources are not included.

Johnson Space Center, and Goddard Space Flight Center's Wallops Flight Facility. Flight operations of Armstrong's science platforms, such as the Stratospheric Observatory for Infrared Astronomy (SOFIA) aircraft and DC-8 aircraft, decreased more than 700 flight hours over the prior year. Similarly, Johnson's Gulfstream G-III aircraft flew 177.4 fewer flight hours and Wallops Flight Facility did not operate its C-23 Sherpa aircraft in FY 2018.

With the Agency aircraft regionalization initiative still taking shape, the synergistic effects of the organization streamlining initiative is not yet apparent. However, FY 2018 flight operations conglomerated into regional organizations are shown in Figures 20 and 21 below. With Johnson Space Center as the lead aircraft center, the Southern Aircraft Region's primary aircraft mission is to support the Agency's Space Operations missions. As evident in the two figures below, the Southern Aircraft Region conducts the bulk of the Agency's overall flight operations. In the Western Aircraft Region, where the main focus of aircraft operations is large-scale and long-duration Airborne Science, as well as major Aeronautics flight research, Armstrong Flight Research Center is the designated lead. With Langley Research Center as the designated lead center, the Eastern Aircraft Region also mainly supports the Agency's Airborne Science missions, but at a smaller scale than the Western Aircraft Region.

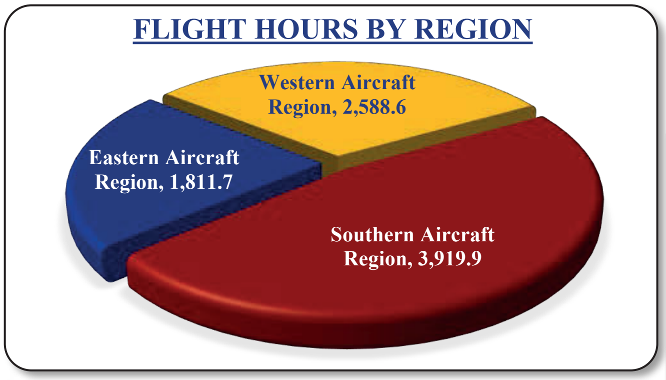
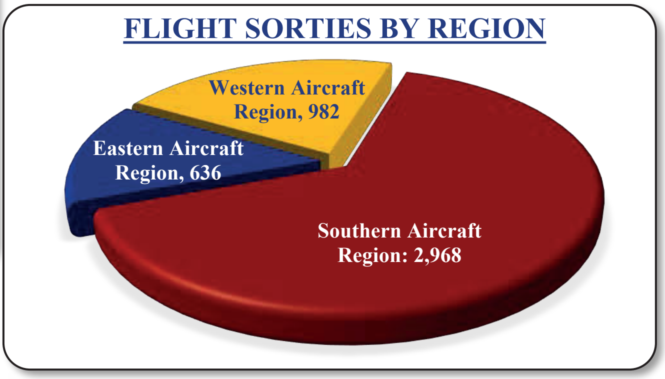


Figure 20 – NASA's FY 2018 Flight Operations (Flight Hours) by Region

Figure 21 – NASA's FY 2018 Flight Operations (Sorties) by Region



NASA's FY 2018 flight operations by individual Centers are shown in Figures 22 and 23 on the following page. As usual, the combined flight activity at the Agency's two largest aircraft operators, Armstrong Flight Research Center and Johnson Space Center, constituted the bulk of the Agency's overall aircraft operations in 2018. These two Centers combined flew 74% of the Agency's total FY 2018 aircraft flight hours and 80% of the total annual flight sorties. At Johnson Space Center, its aircraft activity in support of the Agency's space programs constituted 89% of the center's overall flight operations during the fiscal year. Johnson Space Center's T-38 flight operations in support of NASA's Space Flight Readiness Training (SFRT) program by itself made up 36.2% and 54.5%, respectively, of the Agency's overall FY 2018 flight hours and flight sorties. On the other hand, Armstrong Flight Research Center aircraft operations predominantly supported requirements from the Science Mission Directorate. Flights of Armstrong's three major science platforms, the DC-8, ER-2, and SOFIA aircraft, by themselves, comprised more than 54% of the center's entire FY 2018 reported flight hours.

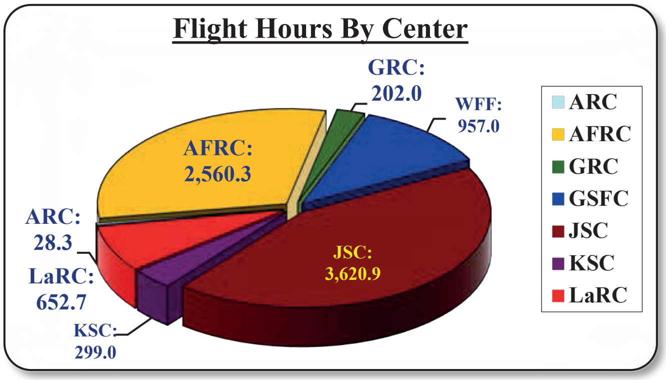
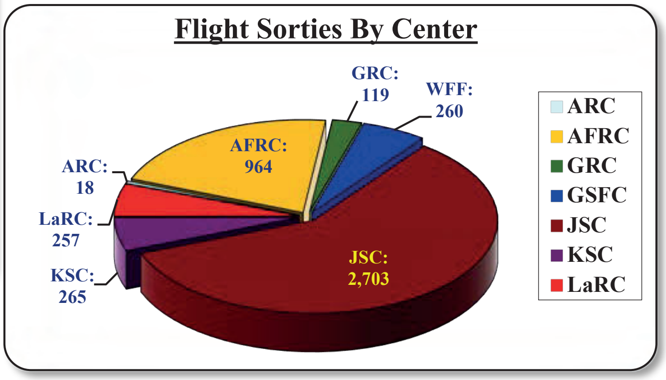


Figure 22 – Flight Hours Flown by NASA's Aviation Community in FY18

Figure 23 – Flight Sorties Flown by NASA's Aviation Community in FY18



The changes in the scope of flight operations over the last decade for each NASA Center are presented in Figures 24 and 25 below. These two figures reflect the dynamic environment NASA's aircraft operators have always faced. The conclusion of the Space Shuttle program, the outsourcing of the Reduced Gravity Program's flight services requirements, and reduced astronaut space flight training needs stemming from a downsized Astronaut Corps especially impacted the Southern Aircraft Region. Johnson Space Center's flight operations decreased 68% and 67%, respectively, in terms of flight hours and flight sorties, from FY 2005 to FY 2018. The significant drop in reimbursable work for Johnson's WB-57 program in the last four years also contributed to the center's reduction in aircraft operations. Reflecting the same reduced Space Operation support requirements, Kennedy Space Center also reported reduced operations of the center's three helicopters. Despite reporting a further decrease in its FY 2018 flight sorties, Kennedy's helicopter operations did show a slight rise in flight hours for the fiscal year. Combined Johnson Space Center's report of a slight increase in flight sorties in FY 2018 as a result of increased T-38 operations, FY 2018 may be an inflection point for the Southern Aircraft Region's flight operations.

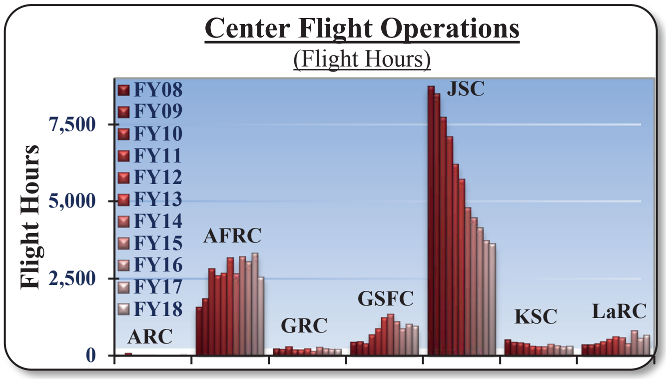
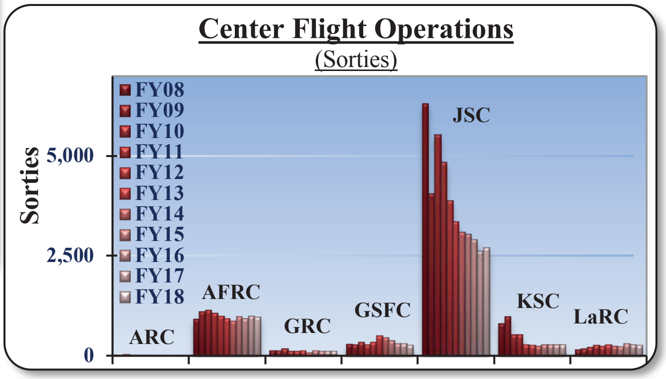


Figure 24 – Trends of Center Aircraft Operations (Flight Hours) from FY08 to FY18

Figure 25 – Trends of Center Aircraft Operations (Sorties) from FY08 to FY18



The Eastern and Western Aircraft Regions also have not been immune to dramatic shifts in flight requirements. In response to sharp rise in Science missions, Langley Research Center and Armstrong Flight Research Center both reported rising flight operations from FY 2008 to FY 2016 as shown in Figures 24 and 25 on the previous page. Data from FY 2018, however, seemed to paint a picture that the two centers' fortunes have reversed with sharp reductions in flight hours at Armstrong and a small decrease in flight sorties at Langley.

As observed from Figures 24 and 25 on the prior page, every NASA Center has seen their share of volatility in flight operations in the past decade. Figure 26 below clearly illustrates the direct impact to Johnson Space Center's flight operations from reduced space operations in American soil. Marshall Space Flight Center, since it had only ever operated one aircraft in support of the Shuttle Program, ceased manned aircraft operations altogether in FY 2008. While Marshall did in recent years begin operations of small UAS, the center still did not have any reportable aircraft activity in FY 2018. The cessation of Marshall Space Flight Center's manned aircraft operations is shown in Figure 27 below.

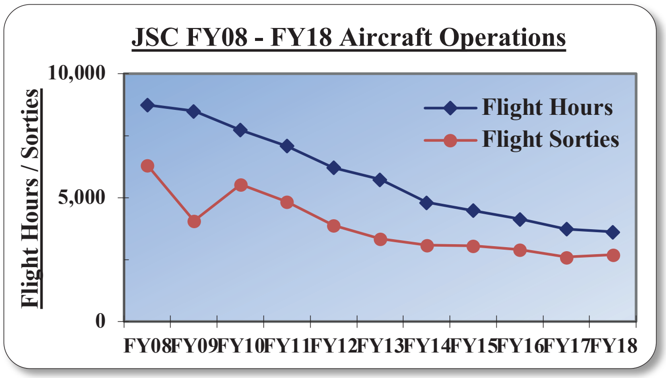
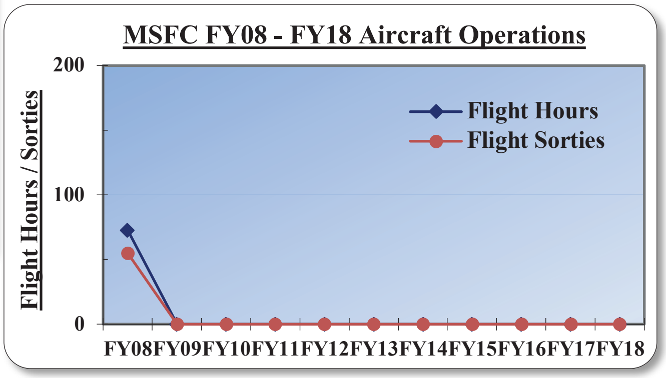


Figure 26 – Trends of JSC Aircraft Operations from FY08 to FY18

Figure 27 – Trends of MSFC Flight Operations from FY08 to FY18



Fluctuations in flight requirements impact centers with small aircraft operations even more keenly. For the past four years, Ames Research Center had been recovering from the UAS mishap that destroyed the center's only Category III UAS and had no reportable flight activity from FY 2015 to FY 2017 as shown in Figure 28 on the next page. However, Ames began flight operations of its SIERRA Ship B UAS in FY 2018 as evidenced by Figure 28. Ames Research Center's modest aircraft operations numbers for the fiscal year may also be an indicator of greater things to come at the center. At Glenn Research Center, its aircraft activities directly correlate with the flight demands from the low Technology Readiness Level (TRL) Aeronautics Research experiments at the center and from flight demonstration work funded by external customers. While Glenn Research Center's aircraft operations have peaked above 250 hours a few times in the last decade, in most years the center's aircraft flew around 200 flight hours a year as shown in Figure 29, also on the following page.

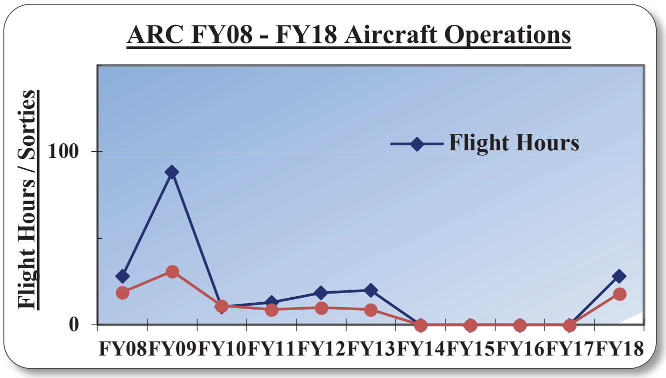
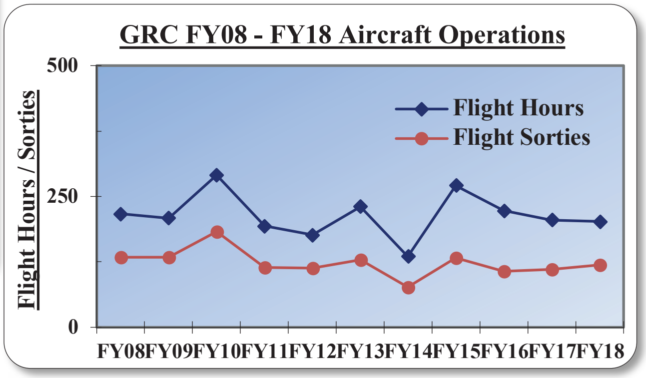


Figure 28 – Trends of ARC Aircraft Operations from FY08 to FY18

Figure 29 – Trends of GRC Aircraft Operations from FY08 to FY18



Several centers benefited from the rising Science flight research requirements in the last decade. As shown in Figure 30 below, Langley Research Center, after being severely impacted by reduced aeronautics research requirements from FY 2005 to FY 2008, saw its aircraft operational tempo rise steadily from FY 2008 to FY 2013 with increased airborne science missions. The center's flight operations rose dramatically in FY 2016 as a result of a number of long oversea deployments, only to drop back down in FY 2017 and yoyo up again in FY 2018, reflecting the fluctuations in Airborne Science requirements. Flight operations at Goddard Space Flight Center's Wallops Flight Facility, as seen in Figure 31, also dramatically expanded its flight operations from FY 2010 to FY 2014 in response to the rising demands of Airborne Science requirements. Flight activities at Wallops Flight Facility have trended down in the last four years, going from its peak of more than 1,300 flight hours a year in FY 2014 to less than 1,000 hours a year from FY 2016 to FY 2018. While Wallops Flight Facility rebounded in FY 2017, its flight operations are expected to continue to trend down in the next few years as a result of several Airborne Science programs that have been supported by facility's C-23 and C-130 aircraft coming to completion.

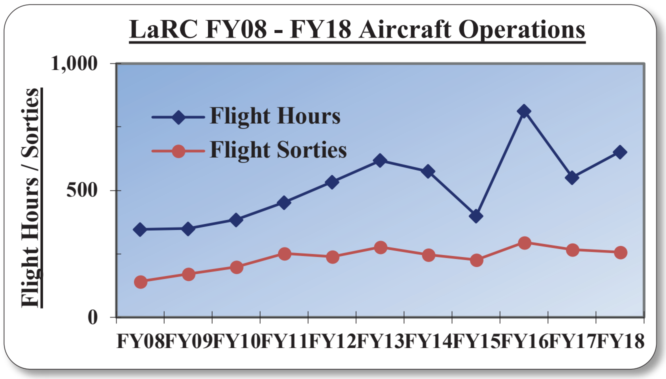
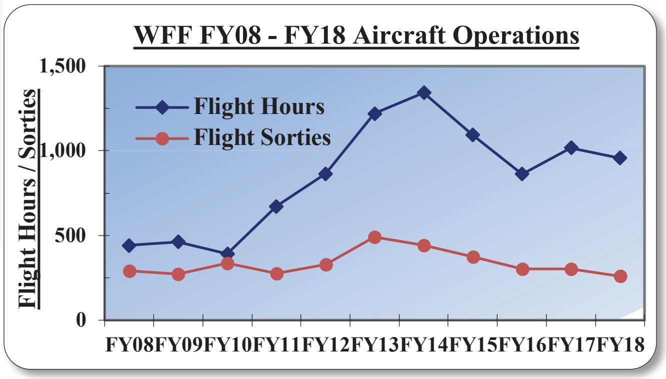


Figure 30 – Trends of LaRC Aircraft Operations from FY08 to FY18

Figure 31 – Trends of GSFC/WFF Flight Operations from FY08 to FY18



Similar to Langley Research Center and Wallops Flight Facility, aircraft operations at Armstrong Flight Research Center in the last decade also transitioned from a center that was largely dedicated to Aeronautics Research to one that mostly conducted Airborne Science research. As seen in Figure 32 below, with rising airborne Science research requirements that was brought about largely by the start of mission operations of the Stratospheric Observatory for Infrared Astronomy (SOFIA), aircraft operations at Armstrong Flight Research Center rose dramatically from FY 2008 to FY 2010 and steadily ever since. The dip in FY 2014 came as a result of a self-imposed safety stand-down of its entire aircraft fleet. The decline in FY 2018, however, resulted from decreasing Science missions, especially for the center's SOFIA aircraft.

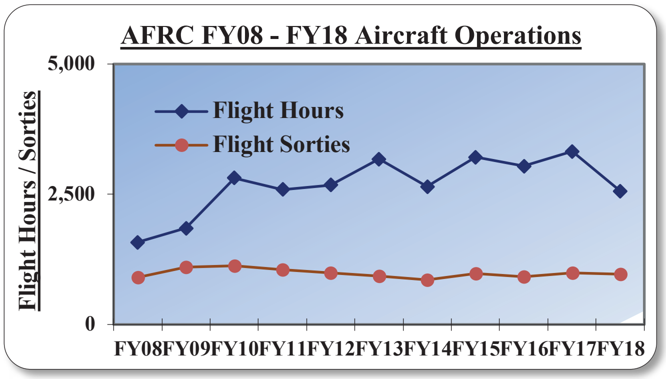


Figure 32 – Trends of AFRC Flight Operations from FY08 to FY18

Commercial Aviation Resources

In FY 2018, NASA also utilized a total of 1,310 flight hours of Commercial Aviation Services (CAS) as defined by the Interagency Committee for Aircraft Policy (ICAP). NASA Jet Propulsion Lab conducted 42% of the Agency's FY 2018 CAS flights, while Goddard Space Flight Center's Wallops Flight Facility conducted the other 58%. The Agency's reported FY 2018 CAS operation was contracted entirely to meet Airborne Science requirements. As seen in Figure 33, NASA's CAS utilization has steadily trended up in the last six years, partly due to better reporting by NASA's centers, and will continue to be a significant contributor to NASA's flight capability.

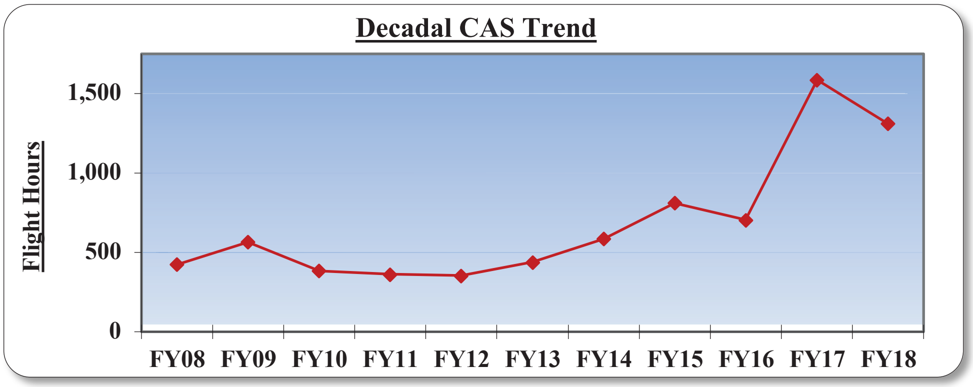


Figure 33 – CAS Trend from FY08 to FY18

Missions Accomplished

In FY 2018, NASA's aircraft and their operators prepared our astronauts for space flight; explored the far reaches of the universe; investigated the changing environments of Earth; and tested new Aeronautics technologies to make future aircraft safer and more efficient. In the advancement of Aeronautics, Armstrong Flight Research Center's F-18 aircraft helped characterize sonic booms and paved the way for the development of low-boom technologies. The center's X-56 Multi-Utility Technology Testbed (MUTT) demonstrated flutter suppression technology, which could potentially allow lighter weight, flexible wing designs to conserve fuel. Armstrong's F-18 aircraft also supported the DOD in understanding the causes of hypoxia incidents in T-6 aircraft equipped with On Board Oxygen Generating Systems (OBOGS). At Glenn Research Center, its S-3 aircraft flight tested communication technologies to enable future integration of UAS into the National Air Space (NAS).

For Science, Armstrong Flight Research Center's C-20 and Johnson Space Center's G-III aircraft responded to the largest eruption of the Kilauea volcano in nearly 200 years. These two NASA aircraft measured lava effusion and provided situational awareness for the people on the Big Island of Hawaii. Armstrong's DC-8 aircraft completed the fourth and final Atmospheric Tomography Mission (ATom) deployment. Over the four ATom deployments in a three-year period, the DC-8 probed the most remote parts of the atmosphere and detected subtle influences of human-produced air pollution around the globe. In addition, Langley Research Center's B-200 and Wallops Flight Facility's C-130 aircraft, carrying in-situ sensors, flew 334 quasi-vertical profiles of greenhouse gases and meteorological variables over the U.S. South, Mid-West, and Mid-Atlantic Regions. At the South Pole, Wallops P-3 aircraft logged 11 research flights, totaling 156 flight hours, and traveled a distance of 85,106 km to map the retreating sea ice.

For our nation's human space exploration objectives, Johnson Space Center put NASA, International, and Commercial astronauts through the Agency's Space Flight Readiness Training (SFRT) program in its fleet of T-38 aircraft and prepare them for missions to the International Space Station. Johnson's Gulfstream G-III and G-V aircraft, modified with medical equipment, returned International Space Station astronauts directly to Houston upon their landing in the Russian Soyuz spacecraft. Paving the way for future manned space launches from the U.S., Johnson's Super Guppy aircraft transported Orion components, including the EM-2 Heatshield Skin from Denver, Colorado to Sunnyvale, California. In addition, Kennedy Space Center's helicopters provided security services for space launches from the space center.

Enabling the Agency's Education Outreach missions, NASA educated California science teachers on board of Armstrong's SOFIA aircraft as a part of the Airborne Astronomy Ambassadors Program. For the Agency's longstanding Student Airborne Research Program (SARP), Armstrong's DC-8 took 28 college and university students up in the skies over the Los Angeles Basin and California's Central Valley and sampled atmospheric gases and assessed the air quality of those regions.

The accomplishments highlighted above were but a few notable achievements by the Agency's aircraft operators in FY 2018. A highlight of the key missions performed for each of the Agency's Mission Directorates are listed in Table 2 on the following page and a more detailed summary of the FY 2018 aircraft missions is provided in Appendix 3 of this report.

Table 2 - Missions Performed by NASA's Aviation Community in Fiscal Year 2018

SPACE OPERATIONS MISSION DIRECTORATE	AERONAUTICS RESEARCH MISSION DIRECTORATE	SCIENCE MISSION DIRECTORATE	EDUCATION AND OUTREACH	NATIONAL & INTERNATIONAL
Astronaut Space Flight Readiness Training (SFRT) on Johnson Space Center's fleet of T-38 and WB-57 Aircraft.	Flutter suppression research using Armstrong's X-56 Multi-Utility Technology Testbed (MUTT) aircraft.	Operation Ice Bridge (OIB) Antarctic campaign with Wallops' P-3 aircraft.	NASA Student Airborne Research Program (SARP) campaign with Armstrong's DC-8 aircraft.	Measurement of lava effusion from Kilauea Volcano eruption using Armstrong's C-20 and Johnson's G-III aircraft/
KSC Space Launch Security Operations Using Kennedy Space Center's three Huey II Helicopters.	UAS surrogate flights using Langley's SR-22 aircraft.	Aerosol Characterization from Polarimeter and Lidar (ACEPOL) prototyping on Armstrong's ER-2 aircraft.	NASA Airborne Astronomy Ambassadors Program with Armstrong's SOFIA Aircraft.	Investigation into DOD T-6 aircraft pilot hypoxia using Armstrong's F/A-18 aircraft.
International Space Station (ISS) Crew Direct Returns from Kazakhstan on Johnson Space Center's Gulfstream G-III and G-V Aircraft.	UAS Traffic Management Technology Development Using Small UAS at Multiple NASA Centers.	Atmospheric Carbon and Transport – America (ACT-America) field campaign with Wallop's C-130 and Langley's B-200 aircraft.	Langley Research Center's Multidisciplinary Aeronautics Research Team Initiative (MARTI) 's sUAS test flights.	Airlifts of USAF T-38 aircraft with fuel contamination by Johnson's Guppy aircraft to El Paso for repair.
Orion and SLS component transport by Johnson Space Center's Super Guppy aircraft.	Sonic boom characterization flights by Armstrong's F/A-18 aircraft.	Deployment of Armstrong Flight Research Center's SOFIA Aircraft to New Zealand for Southern Hemisphere astronomy.	Flybys of Glenn Research Center's S-3 aircraft at AirVenture Oshkosh 2018.	Training of Navy test pilot on Johnson Space Center's WB-57 aircraft.
Out of Control Flight training for NASA astronauts using GRC T-34 aircraft.	High Ice Water Content (HIWC) research using Armstrong's DC-8 aircraft.	Long Island Sound Tropospheric Ozone Sutdy using Langley's HU-25 aircraft.	Fly-over of Armstrong Flight Research Center's ER-2 aircraft at the 2018 Los Angeles County Air Show.	Flight test of EPA's Triple Pulsed Integrated Path Differential Absorption (IPDA) LIDAR on LarC B-200.
	Flight Control Law Development Using Langley Research Cente's Small UAS.	Atmospheric Tomography (ATom) field campaigns using Armstrong's DC-8 aircraft.		Currency and proficiency training of USAF pilots on Johnson's Gulfstream G-V aircraft.
	UAS Detect and Avoid technology demonstration using Armstrong's Ikhana UAS.	Ocean surface current measurements in the Gulf of Mexico using Armstrong's B-200 aircraft.		Commercial and international astronaut training on Johnson's T-38 aircraft.

VII. AVIATION METRICS

The primary measures for NASA's aircraft operations are safety, cost and operational effectiveness. Of these, the one metric that is the most critical to the Agency is safety. The costs reported by the Centers for FY 2018 reflect the varied and unique missions of the Agency's aircraft operations. The costs to accomplish those missions vary widely depending on the nature of the missions, complexity of modification required on the aircraft, operational tempo, and many other factors, and would not provide meaningful comparisons of the Agency's aircraft operations to commercial aviation or to other federal agencies' flight organizations.

Similarly, due to the extreme diversity of NASA's flight operations, the usual aircraft operational measures are not particularly appropriate or useful. Typical industry utilization metrics, such as flight hours and sorties for aircraft utilization and costs per flight hour or costs per seat mile for efficiency, are not applicable to the Agency's unique aircraft operational needs and requirements. The Super Guppy at Johnson Space Center typifies that uniqueness. The Super Guppy is only used to transport outsize cargo for the Agency's Orion program. So, the frequency of the Super Guppy's use is low. Yet, when the need arises, the Super Guppy is invaluable.

Additionally, while flight time is a good aircraft utilization indicator for high volume operations, the metric does not tell the whole story with regard to requirements for NASA to retain an aircraft. For example, flight tests for aeronautics technology incubator projects involve an iterative approach with the associated ground facility. In many instances, equipment will be moved back and forth between a test cell and aircraft many times, with taxi tests and integrated ground tests before the equipment is actually flown, sometimes even grounding the aircraft during the process. To better characterize the unique nature of NASA's aircraft operations, ground utilization measures will be incorporated in future reports.

Ultimately, the aircraft cost and performance measures are only useful when viewed in terms of program accomplishments, i.e. did the flights enable the scientists, engineers, astronauts, or programs to carry out their planned agenda, which would be contained in individual program reports. The cost and performance metrics are presented in this report to characterize the overall scope and trends of the Agency's aircraft operations.

Aviation Safety

For aviation safety, NASA measures Aviation Mishaps by mishap types (Types A, B, C, and D in accordance with NASA Procedural Requirements for Mishap Reporting, Investigating, and Recordkeeping (NPR 8621.1C). Mishaps are differentiated based on severity of damage or injury, with Type D mishaps being the least severe and Type A mishaps the most severe. Type A mishaps include those with loss of life or aircraft, or property damage exceeding $2,000,000. Type B mishaps are those that resulted in costs that are more than $500,000, but less than $2,000,000, or permanent partial disabilities. Type C mishaps are those with costs that are less than $500,000, but more than $50,000. Lastly, Type D mishaps are events with property damage exceeding

$20,000, but less than $50,000. The Type D mishap category dollar thresholds were recently updated in July of 2013 to be more consistent with other DOD agencies.

NASA's aviation safety trends for manned aircraft flight operations during the last decade are presented in Figure 34 below. The Agency's aviation community again avoided any Type A or Type B mishaps in operating the Agency's aircraft in FY 2018. NASA, however, did incur five (5) Type C mishap and six (6) Type D mishaps. However, out of these eleven mishaps, but for one Type C mishap and one Type D mishap, all were ground mishaps during maintenance. The one Type C mishap involved an in-flight electrical short in an under-wing science instrument pod on Armstrong Flight Research Center's C-20 aircraft. The Type D mishap was an in-flight hypoxia event involving a Langley Research Center B-200 aircraft that drew immediate management attention, with mitigations measures implemented as a result.

NASA's aircraft safety record has been exemplary in the last two decades. NASA has not had a Type A aircraft mishap since 1995 and the Agency's last Type B mishap in 2010 was a ground mishap as a result of Foreign Object Damage (FOD). The two FY 2016 aircraft mishaps and three in FY 2017 indicated NASA aircraft operators' continued dedication to safety. In comparison to the tremendous safety performance, the Class C and Class D mishaps in FY 2018 stood out. However, as NASA's aviation community have observed, most of the mishaps in the last year and prior were ground related falls, bumps, and strains. With the aim of reducing ground safety incidents, the Inter-Center Aircraft Operations Panel (IAOP) tasked the Maintenance Subpanel to implement Maintenance Resource Management (MRM) training across the Agency.

Zero Type A mishaps in last 15 years and zero Type B mishaps since FY 2010.

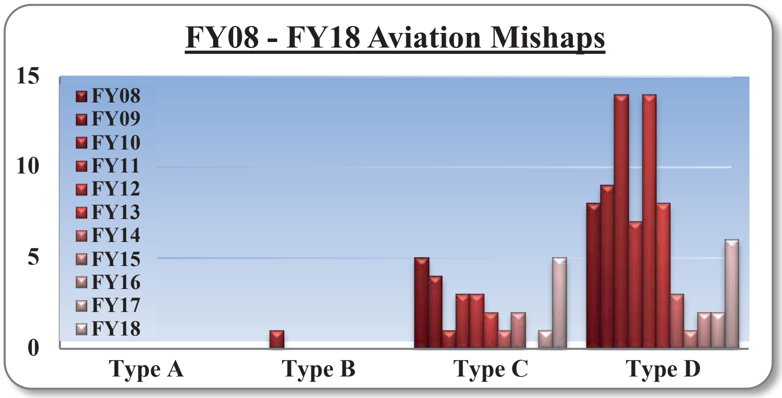


Figure 34 – NASA's FY08 to FY18 Aircraft Mishaps Categorized by Type

NASA's mishap statistics, expressed in mishaps per thousand flights in Figure 35 on the next page, mirrors that of the mishap totals shown in Figure 34 above. The Agency's overall aircraft safety statistics over the past decade continued to be much better than the comparable records of the U.S. military services or those of the civilian aircraft operators flying similar aircraft and conducting similar missions. NASA's FY 2018 aircraft mishap rates, while noticeably high

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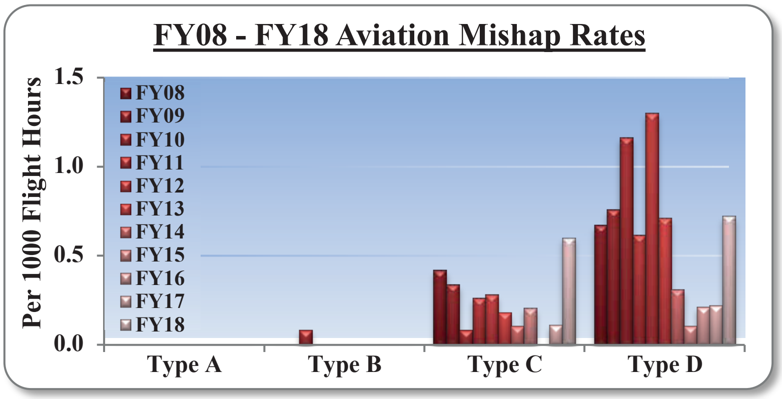
[3] Small UAS and non-NASA aircraft incidents and accidents excluded.

in comparison to the historic low rates in the previous two years, was still quite low relative to the rest of U.S. aviation industry.



Only two flight mishaps, one Class C and one Class D, in FY 2018.

Figure 35 – NASA FY08 to FY18 Aircraft Mishap Rates (per 1,000 Flight Hours)

While the number of mishap occurrences and mishap rates are good indicators of safety performance, management of aviation safety must also be based on the nature and the specifics of the mishaps. Nine of the eleven FY 2018 aircraft mishaps, each briefly described in Table 3 below, demonstrated NASA's aircraft are safe for flight. However, the increased ground incidents during aircraft maintenance also highlight the need to improve ground safety of the Agency's aircraft operations without losing NASA's high standards of flight safety.

Table 3 – FY 2018 Aviation Mishaps

Mishap Type	Mishap Category	Brief Description
Type C	Flight	In flight electrical short in the external UAVSAR instrument pod on AFRC C-20.
	Ground	AFRC maintainer fell while ER-2 crew access platform was being moved.
		JSC maintainer injured knee while taping lower intake (RH) paper to paint strips.
		JSC maintainer sustained lower back injury while disconnecting power cord.
		Maintainer fell from 3-foot ladder during aircraft maintenance.
Type D	Flight	In flight hypoxia event in LaRC B-200 as a result of operator error.
	Ground	AFRC maintainer hit by a propeller blade while working in hangar.
		JSC maintainer fell after removing aircraft from tow bar equipment.
		AFRC maintainer hit his head on G-III nose gear door.
		JSC maintainer hit his head on T-38 antenna
		AFRC maintainer hit his head on F-15D antenna.

Aviation Costs

In FY 2018, NASA Centers reported a total of $161.2M expended on the Agency's aviation programs in operating, maintaining, and upgrading the Agency's aircraft. This total also included the acquisition of flight services from commercial aviation vendors and the use of military airlift support during the fiscal year. The total aviation expenditure reported for FY 2018 declined by 5.3%, or $9.0M, in comparison with the prior fiscal year, continuing the $6.0M cost decrease observed in FY 2017. NASA's increased aviation expenditures in FY 2016 were almost entirely driven by Johnson Space Center's purchase of a used Gulfstream G-V aircraft, the re-wing of Goddard Space Flight Center's P-3 aircraft, and Armstrong Flight Research Center's acquisition of a used Gulfstream G-III. Without these one-time recapitalization expenditures, compounded with reduced operations of several major Science platforms, aircraft operational cost decreases in FY 2017 and FY 2018, and even beyond, were only to be expected.

The aircraft cost trend for the past decade is captured in Figure 36 below, broken down by how much was spent to directly fund contractors and commercial procurements and how much funded expenditures internal to the Federal Government, such as civil servant salaries. NASA's overall aircraft operations expenditures in the last decade showed that, with the exception of the one-time increase in aircraft investment expenditures in FY 2016, NASA contained its aviation cost growth in the last five years after a steady rise from FY 2009 to FY 2013. While the fluctuating aircraft expenditures do reflect the constant changes in aircraft operational requirements across the Agency, the rise and fall of aircraft costs also include accounting instabilities stemming from accounting practice changes, such as Full Cost Accounting and then Full Cost Simplification in the last decade or so. In addition, in FY 2014 Armstrong Flight Research Center adopted a new overhead cost allocation methodology that simplified their cost reporting process and discontinued its reliance on consultant support in overhead cost accounting.

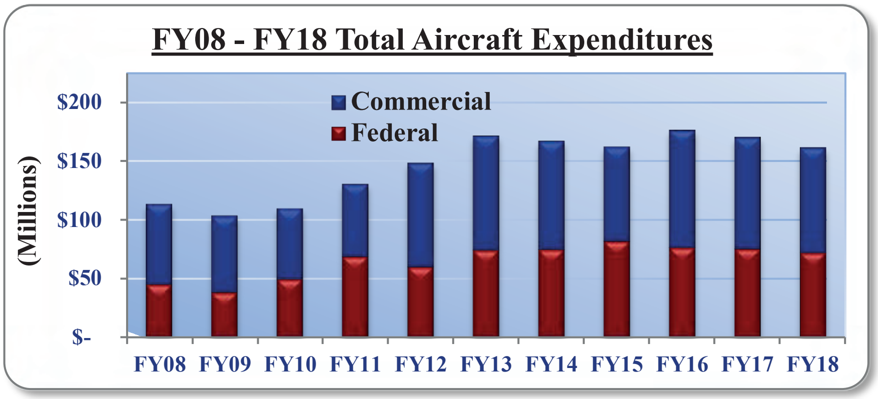


Figure 36 – NASA's Aviation Expenditures in the Last Decade

As shown by Figure 37 on the next page, more than half, or $89.4M, of the total FY 2018 expenditures were paid directly to commercial vendors, and 45%, or $71.8M, were used to fund the Agency's internal flight organizations or were paid to other federal agencies. While the ratio between commercial support and internal NASA resources varied over the last decade, Figures 36 and 37 showed that the Agency's flight operations had and continued to rely heavily on contractor provided services.

NASA's aircraft expenses in FY18 totaled $161.2M.

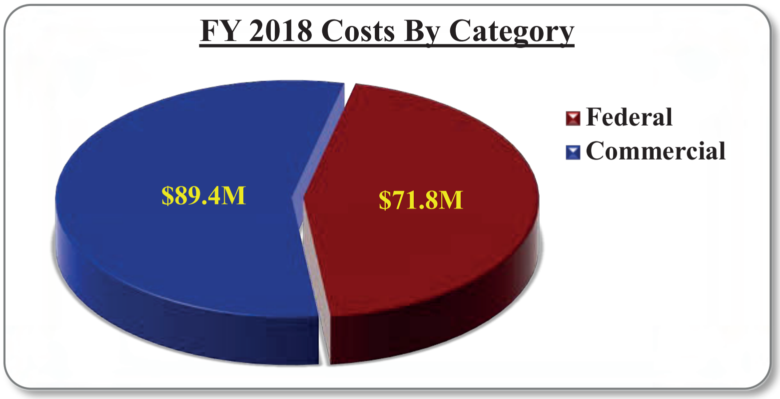
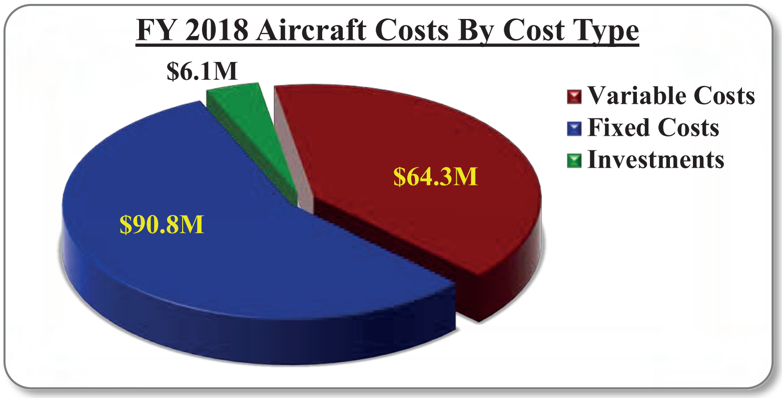


Figure 37 – NASA's Total FY18 Aviation Expenditures

About 56%, or $90.8M, of the Agency's aviation expenditures in FY 2018, as shown in Figure 38 below, funded the Fixed Costs of operating NASA's aircraft. Generally, the two biggest components of Aviation Fixed Costs have been Aircraft Operations Overhead, which covered management and administrative staff salaries, facilities, and utilities, and Fixed Maintenance, which covered maintenance crew salaries and calendar-based maintenance actions. In FY 2018, contracted maintenance support labor costs and aircraft parts acquired from commercial vendors alone accounted for more than 43% of the fiscal year's total Aviation Fixed Costs, with allocated administrative overhead costs making up another 17%. Investment Expenditures and Variable Costs made up 4% and 40%, respectively, of NASA's total aircraft costs for FY 2018.

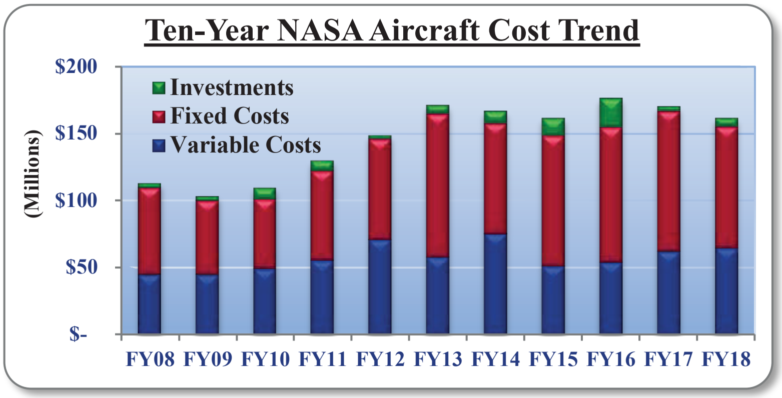


Admin and Operational Overhead Costs Made up 36% of all FY 2018 Fixed Costs.

Figure 38 – FY18 Aviation Investments & Costs

Compared to FY 2017, the Agency's total aviation expenses for FY 2018 fell 5.3%, or $9.0M, as stated earlier, entirely as a result of decreased aircraft expenditures at Armstrong Flight Research Center and Johnson Space Center, but offset by higher costs at Langley Research Center and Goddard Space Flight Center's Wallops Flight Facility. In addition, the Agency's investment in aircraft modification and modernization in FY 2018 also increased by $2.6M to $6.1M in comparison with the prior year as shown in Figure 39 below.

NASA's aircraft investments in the last two years may appear paltry, but they were actually close to the norm of the last decade as seen in Figure 39. It was the dramatic, but temporary, investment increase in FY 2016 that was unique as Armstrong Flight Research Center's acquisition of a used G-III aircraft and Johnson Space Center's acquisition of a used G-V during FY 2016 were the only aircraft purchases by NASA in the last decade.



AFRC's acquired a used G-III aircraft for $1.25M and JSC purchase a used G-V aircraft for $12.9M in FY16.

Figure 39 – FY08 to FY18 Aviation Costs

Also evident in Figure 39, NASA's aircraft costs consistently increased until to FY 2013, as a result of rising Airborne Science requirements and reimbursable customer demands. The downward cost trend from FY 2013 to FY 2015, was almost entirely the result of a sharp drop in reimbursable work for Johnson Space Center's WB-57 program. In FY 2013, Johnson's WB-57 aircraft flew 1,322 hours, at a reported cost of $64.1M; but by FY 2015, the WB-57 program had shrunk to just 275.9 flight hours for the fiscal year, with an annual cost of $13.6M. The latest cost decline from FY 2016 to FY 2018 was driven by reduced Science mission needs. For example, in comparison with the prior fiscal year, Armstrong Flight Research Center reported a combined $8.6M operational cost decrease for the center's four major Science platforms, the C-20, DC-8, ER-2, and SOFIA aircraft, for FY 2018.

With the fiscal year's aviation expenditures segregated by NASA Centers, as shown in Figure 40 on the next page, it was not surprising that Armstrong Flight Research and Johnson Space Center Center's aviation costs still comprised a significant portion, or just over 78% of NASA's total FY 2018 aviation expenses, as these two Centers combined flew 74% of the Agency's total aircraft flight hours and 80% of the total aircraft flight sorties during the fiscal year. Armstrong Flight Research Center overtook Johnson Space Center in annual operating costs for the first time in FY 2017 as Johnson's T-38 and WB-57 aircraft saw several years of declining utilization. Even with a sharp drop in Science requirements, aircraft costs at Armstrong Flight Research Center just edged out Johnson Space Center's reported costs for FY 2018. Goddard Space Flight Center's Wallops Flight Facility, while also seeing its costs drop with reduced

Airborne Science requirements, was still the third largest aircraft center by cost and scope of operation.

Combined aircraft expenses at AFRC and JSC comprised just over 78% of the Agency's total FY 18 aviation expenditure.

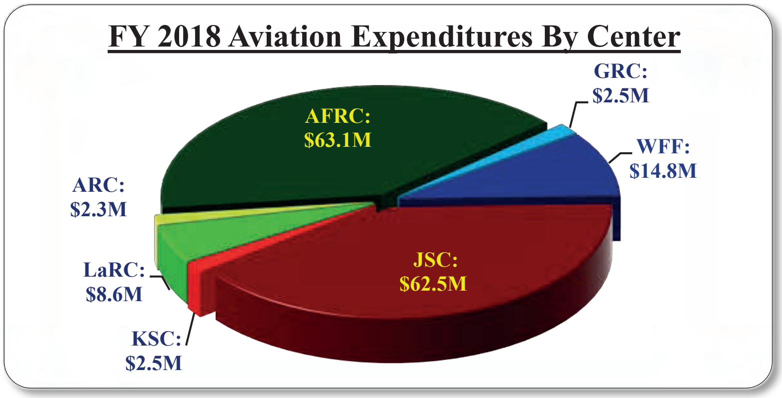


Figure 40 – FY18 Center Aviation Costs

The expenditures in Figure 40 also reflected the diverse nature of aircraft operations across the Agency. For instance, Johnson Space Center operated the Agency's largest fleet of Program Support aircraft comprised largely of T-38 training jets in support of Space Operations, while Langley Research Center operated a small fleet of aircraft only for R&D projects. Even within the R&D aircraft operations environment, there were variations in how the missions are conducted. For example, Armstrong Flight Research Center's SOFIA aircraft is the only flying telescope in NASA, operating at night for long durations. The DC-8 aircraft operated by Armstrong and the P-3 aircraft operated out of Goddard's Wallops Flight Facility, while providing great flexibility in terms of science payloads, required unique integration for each research mission. The WB-57 aircraft at Johnson Space Center, on the other hand, utilized a palletized payload system and required less integration per mission.

The ten-year aircraft expenditure trends at each Center, as shown by Figure 41 on the next page, conveyed the budget and program volatilities that NASA's aircraft operators faced in the last decade. In a three-year span, aircraft operations at Ames Research Center went from a single large aircraft program, the SOFIA, to a much more limited scope of small UAS operations just before FY 2008. Marshall Space Flight Center ceased manned aircraft operations in FY 2008 with the outsourcing of the Agency's Mission Management Aircraft requirements. Langley Research Center, with the disposal of its Boeing 757 Aries aircraft in FY 2006, bore the brunt of the aeronautics flight research budget cuts as its aircraft operations expenditures fell by half in FY 2007. Langley's aircraft operations continued the decline until FY 2011, when the Center saw a gradual, but steady rebound of flight activity that came as a result of growing Airborne Science missions.

Outpacing even Langley Research Center's expansion in the last ten years, the scope of aircraft operations at Goddard Flight Research Center's Wallops Flight Facility and Armstrong Flight Research Center both climbed sharply in response to airborne science demands. In the last several years, however, flight operations at both Armstrong and Wallops have experienced declining flight requirements, as evidenced by the lower aircraft costs for both centers.

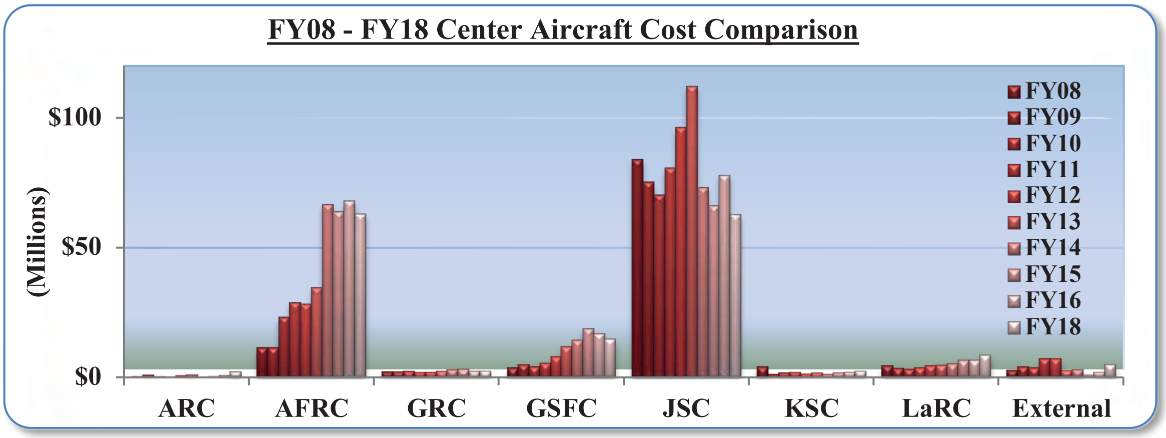


Figure 41 – FY08 to FY18 Center Aviation Cost Comparison

The budget and program volatilities that NASA's aircraft operators must respond to are even more dramatic when looked at individually. Deceptively, Figure 42 showed relatively low, but growing, UAS operations at Ames Research Center and Figure 43 showed a steady expansion of Langley Research Center's flight operations over the last decade. What is not shown by either figure was that from FY 2006 to FY 2007, Ames' aircraft operations expenditures dramatically dropped by 93% and Langley Research Center lost 68% of its aircraft business.

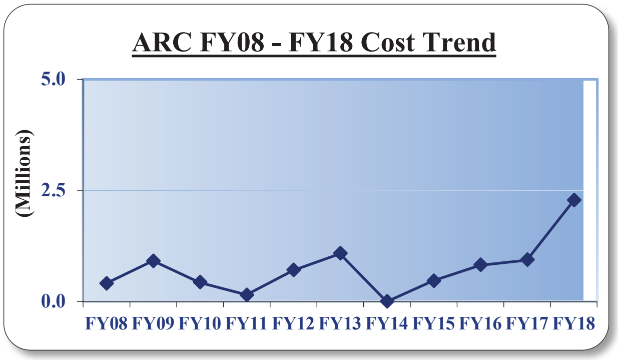


Figure 42 – ARC Decadal Cost Trend

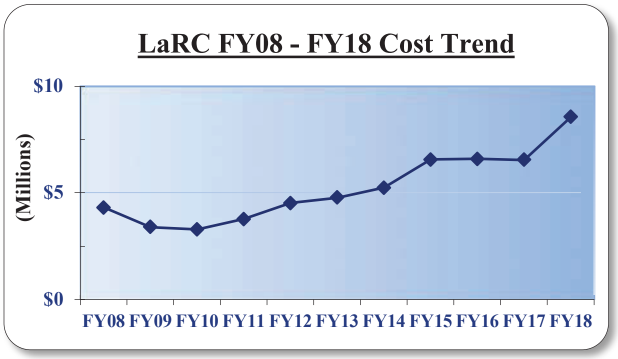


Figure 43 – LaRC Decadal Cost Trend

From the $56M in FY 2004 aircraft operational expenditures, Armstrong Flight Research Center reported a breathtaking 71% decline in its aircraft expenditures the following year in FY 2005. However, as seen in Figure 44 on the next page, from the low points between FY 2008 and FY 2009, Armstrong's flight operations experienced a steep rise in aircraft costs for most of the last ten years that came as a result of rapidly expanding airborne science missions. The continued rise in Armstrong's reported FY 2017 operating costs came mostly as a result of higher aircraft maintenance costs across the board of the center's Airborne Science platforms, but began to show a decline in FY 2018. Similarly, at Goddard Space Flight Center's Wallops Flight Facility, the center's aircraft operations have expanded dramatically in scope in the last decade, more than tripling their aircraft operations and associated expenditures from FY 2008 to FY 2016, only to fall in FY 2016 and FY 2017 as seen in Figure 45. The uptick in Wallops' aircraft costs in FY 2018 that came despite of contracting flight activity was the result of higher unscheduled aircraft repair costs and a spike in fuel costs.

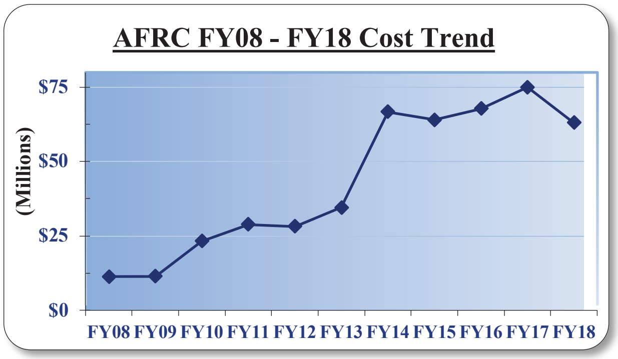


Figure 44 – AFRC Decadal Cost Trend

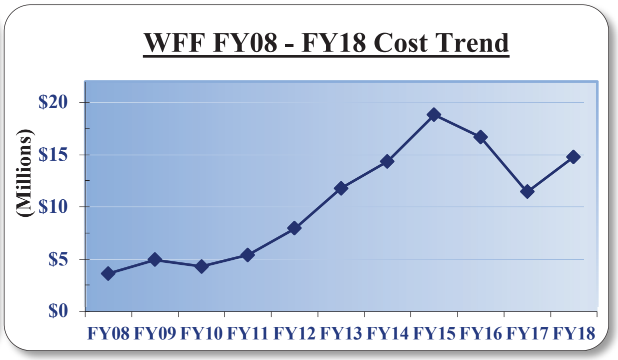


Figure 45 – GSFC/WFF Decadal Cost Trend

NASA's use of Commercial Aviation Services, or CAS, also waxes and wanes in response to the Agency's fluctuating requirements as seen in Figure 46 below. Within the last ten years, NASA's reported CAS costs peaked close to $7.5M in FY 2010, dipped below $800K in FY 2015, only to bounce back up to $5.9M and $5.0M, respectively, in FY 2017 and FY 2018.

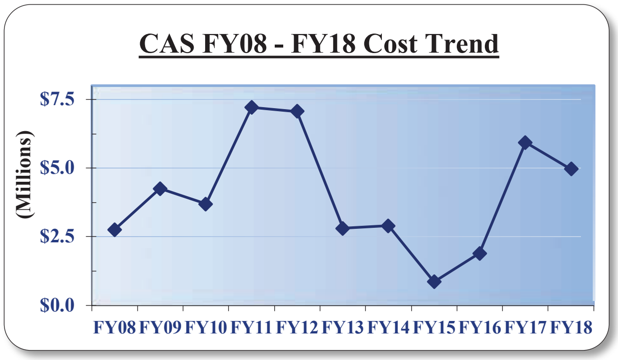


Figure 46 – Decadal CAS Cost Trend

Continuously evolving aircraft missions, and corresponding swings in aircraft operation expenditures, at the Centers have become the only constant for the Agency's aircraft operators. Just as the termination of the Space Shuttle Program and its successor, the Constellation Program, and the resultant budget swings, changing national focus, such as the new vision of using the moon as a stepping stone to reach Mars, will exert unrelenting pressure to reshape NASA's aircraft operations in pursuit of NASA's new priorities.

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VIII. AIRCRAFT REQUIREMENTS ANALYSIS

NASA’s Aircraft Operations involves a diverse fleet of aircraft and infrastructure with operations performed primarily at Armstrong Flight Research Center (AFRC), Ames Research Center (ARC), Glenn Research Center (GRC), Goddard Space Flight Center’s (GSFC) Wallops Flight Facility (WFF), Johnson Space Center (JSC), Kennedy Space Center (KSC), Langley Research Center (LaRC), and even Marshall Space Flight Center (MSFC) and Stennis Space Center (SSC) with their sUAS-only operations. NASA field centers manage and implement aircraft operations. NASA Headquarters’ Aircraft Management Division (AMD) establishes and enforces standards for safety as well as maintains the Agency inventory and validates annual usage. NASA-owned aircraft, including UAS, are Agency-wide resources available to support all NASA programs and missions, and each NASA Mission Directorate funds their unique requirements for aircraft. AMD, within the Office of Strategic Infrastructure (OSI), is designated as the Agency-level capability lead for NASA’s aircraft operations. Fulfilling its roles and responsibilities, AMD continually reviews NASA’s aircraft fleet against program and project requirements to ensure the efficient and effective management and use of our aviation assets. This ongoing aircraft-requirements analysis process provides valuable insight to facilitate informed aircraft decisions within the Agency. Per NPR 7900.3, both the Mission Directorates and Center Directors are required to review their aircraft missions and program requirements, use, and associated costs, and project those requirements (including UAS) over a five-year horizon. The Requirements Analysis section of this report evaluates whether active NASA aircraft are meeting funded requirements and that those requirements are linked to NASA’s Strategic Plan.

Seven years ago, under the authority of the NASA Associate Administrator, NASA assembled the Technical Capabilities Assessment Team. This team developed a process for a comprehensive technical capability assessment to identify and evaluate Center technical capabilities, including aircraft, against the current and future needs of the Agency. This comprehensive assessment, which began in July 2012, evaluated Center capabilities against Agency strategic goals and long-term needs. The outcomes of this ongoing process fed into NASA's master planning activities and supported strategic facilities investment decisions. By engaging the Technical Capability Assessment Team (TCAT), NASA established a process to strategically assess the diverse technical capabilities, including aircraft assets, required to support Agency goals. Furthermore, this disciplined method enabled NASA leadership to make informed decisions on investing/divesting strategically within the budget while strengthening innovation in critical areas needed to advance our mission.

Specific to the Agency’s aircraft operations, TCAT recommended the coordination and integration of flight operations throughout NASA. Based on this recommendation, the Mission Support Council (MSC) expanded AMD’s responsibilities and accountability in order to enable a single Agency-level portfolio coordinating body for Aircraft Operations. The scope of this responsibility included the full range of NASA aircraft needs, including science, testing, training, chase, and other mission support. This new capability leadership responsibility was added to

AMD's existing roles, which included aircraft acquisition and disposal, management of agency aircraft inventory, validating aircraft annual usage, and implementing NASA policies and procedures related to aircraft operations.

To discharge this "Capability Lead" responsibility, an additional level of integrated requirements-review, the Aircraft Advisory Committee (AAC), has been added to AMD's continuous requirements review process for FY 2015 and beyond. The AAC, chaired by AMD and with the Inter-Center Aircraft Operations Panel (IAOP) as core members, was chartered to advise AMD regarding identification of aircraft requirements, prioritization of capability verses requirements, gap analysis for strategic investment, and plans/roadmaps. AAC's membership also includes representatives from the following organizations:

a. Aeronautics Research Mission Directorate
b. Science Mission Directorate
c. Human Exploration and Operations Mission Directorate
d. Space Technology Mission Directorate
e. Office of Safety and Mission Assurance
f. Office of the Chief Engineer

The AAC has employed a top-down systems approach in concert with the Agency strategy to build a framework to efficiently manage and prioritize aircraft assets. Roles and responsibilities of the AAC include:

a. Produce an Agency level baseline of aircraft requirements, including UAS.
b. Balance requirements to aircraft capability and determine areas for fleet right-sizing and strategic investment.
c. Establish roadmap/plans to provide guidance for management of the Agency aircraft fleet.
d. Recommend policy regarding resource sharing, acquisition and disposal, use of other government aircraft/commercial aircraft services and fleet optimization.
e. Review and recommend procedures and methods for effective inter-center aircraft operations.

Annual aircraft requirements assessment had become the Agency standard since FY 2006 and facilitated aircraft resource decision-making. FY 2019 aircraft requirements and projected out-year funding were collected from the Mission Directorates and validated with Center inputs. The FY 2019 requirements analysis, with the AAC's inputs, verified that all active NASA aircraft were operated for funded requirements that were linked to the strategic plan per Appendix 5. Our FY 2019 aircraft requirements review ensured that all aircraft operational requirements corresponded with stated Agency goals in NASA Strategic Plan 2018.

NASA's aircraft support all four of the Agency's strategic goals: *(1) Expand Human Knowledge through New Scientific Discoveries*, *(2) Extend Human Presence Deeper into Space and to the Moon for Sustainable Long-Term Exploration and Utilization*, *(3) Address National Challenges and Catalyze Economic Growth,* and *(4) Optimize Capabilities and Operations.* To develop a balanced overall program of airborne science, space and aeronautics consistent with

Agency's strategic goals, NASA continually adjusts the mix and usage of unique aircraft to efficiently meet the changing requirements. The funding for these requirements comes from a variety of sources, both internal and external to NASA. Figures 47 and 48 below illustrate the main funding stakeholders in FY 2018 and FY 2019. As depicted in these two figures, the primary sources of internal funding for NASA's aircraft operations are still through the Science Mission Directorate (SMD) and the Human Explorations and Operations Mission Directorate (HEOMD). Funding by Aeronautics Research Mission Directorate (ARMD) appears to be on par with HEOMD in FY 2018. However, a significant portion of the funding identified by ARMD goes to basic aviation research and not all slated for actual aircraft operations.

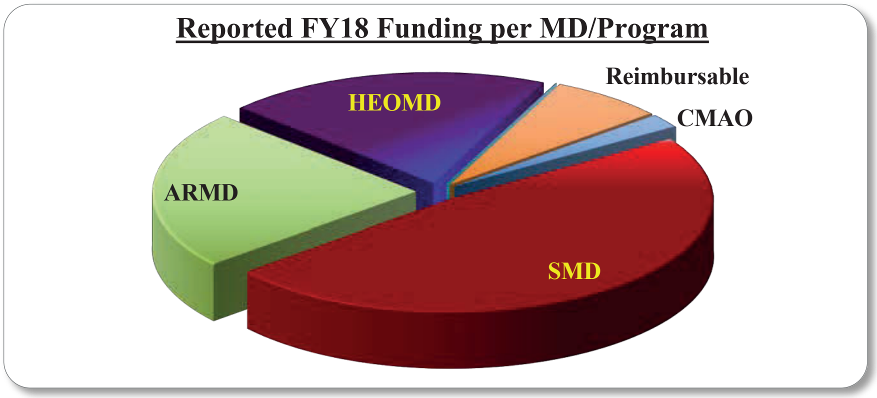

Figure 47 – FY18 Aircraft Funding

Total aircraft funding from all sources has begun to stabilize and is expected to remain relatively consistent for the next several years. Conspicuously missing from both Figures 47 and 48 is the Science and Technology Mission Directorate. With the elimination of Reduced Gravity Program requirements, STMD currently has no identifiable aircraft requirements.

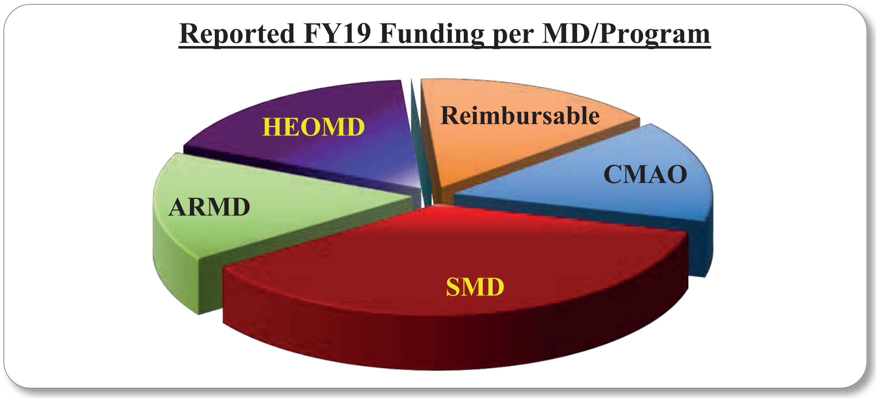

Figure 48 – FY19 Aircraft Funding

Figure 49 on the next page depicts budget projections from both Center and Mission Directorate perspectives over the FY 2019 to FY 2024 timeframe. The projected precipitous decline starting in FY 2020 reflects several Science programs coming to an end by FY 2019.

However, the outyear projection is also somewhat deceptive in that the data only included confirmed and funded requirements for aircraft use. For example, while $23.4M of reimbursable funding for aircraft operations is shown for FY 2019, none is being forecasted in the outyears. In addition, the projection in the figure below also reflects the lag in project and program aircraft selection decision and is highly dependent upon future programs, especially those related to space flight operations and airborne science missions. Space flight operations and airborne science has driven the large majority of the aircraft requirements since the inception of this analysis, with ascendant airborne science flights. Future aircraft activity, however, will certainly be influenced by the planned Moon to Mars initiative.

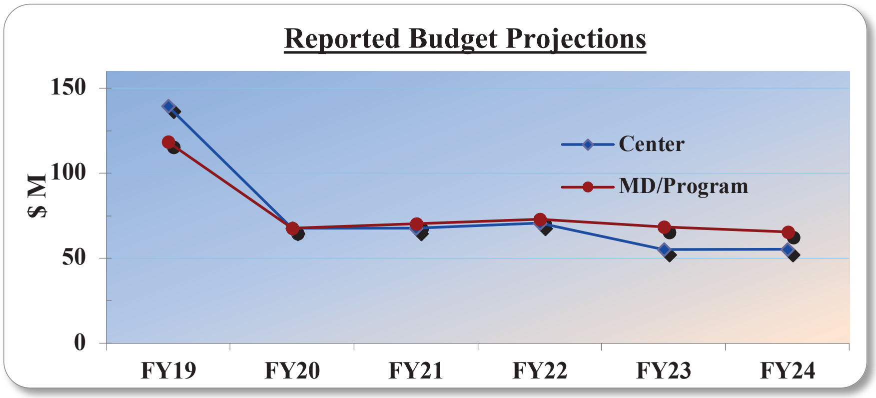

Figure 49 – Aircraft Budget Projections

The FY 2019 funding delta between the Mission Directorate and Center forecasts in Figure 49 above stems from Kennedy Space Center's planned use of $20.3M to acquire new Airbus H-135 helicopters to replace the center's aging Huey II helicopters in meeting its center security missions. The outyear funding to meet aircraft requirements is projected to be approximately $75M with a slight decreasing trend over the next several years. However, as reimbursable agreements and program/project funding commitments are definitized, the actual outyear funding for aircraft requirements should be quite a bit higher.

Aircraft Requirements by Mission Directorate

NASA's aircraft are support assets that directly or indirectly enable the Agency's Mission Directorates to accomplish their program and project objectives. As such the Agency's aircraft operations are almost entirely funded by Programs and Projects. Surprising to people unfamiliar with NASA, SMD has been the largest funding source of the Agency's aircraft operations. However, going forward, SMD's funding in the outyears has been reduced dramatically and aircraft operational funding resources are almost evenly divided between ARMD, HEOMD, and SMD as seen in Figure 50 on the following page. It should be noted, however, that funding projected by ARMD mostly goes to fund basic aviation research and only a small portion ends up funding actual aircraft operations.

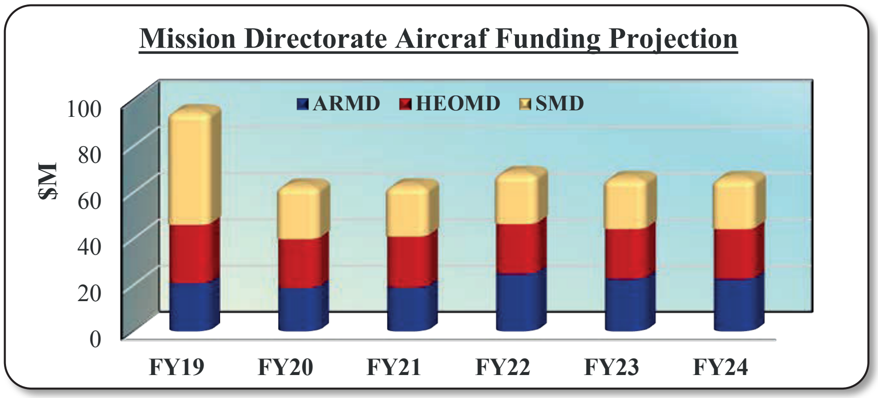

Figure 50 – Outyear Aircraft Budget Projections

Aeronautics Research Mission Directorate (ARMD)

NASA's Aeronautics Research Mission Directorate has developed a new strategic vision for its aeronautics programs that is the culmination of a multi-year effort. Inputs were gathered from industry and other government agencies, including systems analyses of environmental and market trends, and the identification of societal mega-drivers. The consensus of these inputs was that NASA can best contribute to the nation's future societal and economic vitality by focusing aeronautics research in six thrust areas that are responsive to a growing demand for mobility, challenges to the sustainability of energy and the environment, and technology advances in information, communications and automation.

The six areas are:

1. Assured autonomy for aviation transformation
2. Innovation in commercial supersonic aircraft
3. Ultra-efficient commercial vehicles
4. Transition to low-carbon propulsion
5. Real-time system safety assurance
6. Safe, efficient growth in global operations

To effectively manage the research needed to address these six areas, NASA's Aeronautics Research Mission Directorate has restructured itself. Four mission programs – the Airspace Operations and Safety Program (AOSP), the Advanced Air Vehicles Program (AAVP), the Integrated Aviation Systems Program (IASP), and the Transformative Aeronautics Concepts Program (TACP). The objective of these four programs is to clearly define the most compelling technical challenges facing the aviation industry; and overcome these challenges in a time frame that is supported by the stakeholders and required by NASA's customers.

The Airspace Operations and Safety Program (AOSP) creates technologies to help NextGen fulfill its promise. AOSP works with the Federal Aviation Administration (FAA), industry and academic partners to conceive and develop NextGen technologies to improve the intrinsic safety of current and future aircraft. Today's radar-based air traffic control system will transition to one that is satellite-based. NextGen satellite-based technologies will significantly improve safety, capacity, and efficiency on runways and in the nation's skies while providing environmentally friendly procedures and technologies that reduce fuel burn, carbon emissions and noise. The goal of AOSP-developed NextGen methods and means is to provide advanced levels of automated support to air navigation service providers and aircraft operators for reduced air-travel times and air-travel related delays, and to insure greater safety in all weather conditions. By moving key concepts and technologies from the laboratory into the field, AOSP helps to make air travel as safe and efficient as possible, to directly benefit the flying public today and tomorrow.

The Advanced Air Vehicle Program (AAVP) studies, evaluates and develops technologies and capabilities that can be integrated into these aircraft systems, as well as exploring far-future concepts that hold promise for revolutionary improvements to air travel. Environmentally friendly next-generation fixed wing and vertical lift aircraft will be needed as growth accelerates in both domestic and international air transportation. Innovative design concepts developed by AAVP for advanced vehicles integrate multiple, simultaneous vehicle performance considerations that focus on fuel burn, noise, emissions and intrinsic safety. The goal: to enable new aircraft to fly safer, faster, cleaner, quieter, and use fuel far more efficiently. AAVP research primes the technology pipeline, enabling continued U.S. aeronautical leadership, economic competitiveness, and job creation. Partners from industry, academia, and other government agencies are engaged by AAVP to maintain a sufficiently broad perspective on technology solutions to aviation's most pressing needs, to pursue mutually beneficial collaborations, and to leverage opportunities for effective technology transition. The AAVP will be subscribing the following NASA aircraft between FY 2019 and FY 2024:

Aircraft	Project	Center
F-15B/D (N836NA, N897NA)	Commercial Supersonic Transport	AFRC
F-18A/B (N867NA, N868NA)	Commercial Supersonic Transport	AFRC
X-59 QueSST	Commercial Supersonic Transport	AFRC
X-56 (UAS)	Advanced Air Transportation	AFRC

The objective of the Integrated Aviation Systems Program (IASP) is to conduct flight oriented, integrated, system-level research and technology development that supports the flight research needs across the ARMD strategic thrusts, the programs and their projects. The IASP is focused on the rigorous execution of highly complex flight tests and related experiments. The flight tests will support all phases of research, not just the culmination of research activities. For technologies at low Technology Readiness Level, the IASP flight research will accelerate the development and/or assess the feasibility of those technologies. For more mature technologies, it will reduce the risk and accelerate transition of those technologies to industry. The program will also maintain Flight Demonstrations and Capabilities (FDC) and identify other national or international capabilities to meet ARMD, other NASA mission directorates, and national flight test requirements. This program currently includes research into environmentally responsible aviation and Unmanned Aircraft System (UAS) integration into the national airspace (NAS).

The UAS in the NAS project envisions performance-based routine access to all segments of the national airspace for all UAS classes, once all safety-related and technical barriers are overcome. This project will provide critical data to such key stakeholders and customers as the FAA and RTCA Special Committee 203 (formerly the Radio Technical Commission for Aeronautics) by conducting integrated, relevant system-level tests to adequately address safety and operational challenges of national airspace access by unmanned aircraft systems, or UAS. In the process, the project will work with other key stakeholders to define necessary deliverables and products to help enable such access. Within the project, NASA is focusing on five sub-projects. These five focus areas include assurance of safe separation of unmanned aircraft from manned aircraft when flying in the national airspace; safety-critical command and control systems and radio frequencies to enable safe operation of UAS; human factors issues for ground control stations; airworthiness certification standards for UAS avionics and integrated tests and evaluation designed to determine the viability of emerging UAS technology.

Many beneficial civilian applications of UAS have been proposed, from goods delivery and infrastructure surveillance, to search and rescue, and agricultural monitoring. As UAS operations require interactions with a mix of general aviation aircraft, helicopters and gliders, there is a strong need to safely accommodate all of these vehicles at lower altitudes. Currently, there is no established infrastructure to enable and safely manage the widespread use of low-altitude airspace and UAS operations, regardless of the type of UAS. An UAS traffic management (UTM) system for low-altitude airspace is needed, much like today's surface vehicles that operate within a system consisting of roads, lanes, stop signs, rules, and lights, regardless of whether the vehicle is automated or driven by a human. The IASP will be subscribing the following NASA aircraft in the next five years:

Aircraft	Project	Center
B-200 (N7NA, N801NA)	FDC	AFRC
F-15D (N884NA, N897NA)	FDC	AFRC
F-18 (N846NA, N867NA, N868NA)	FDC	AFRC
G-III (N804NA)	FDC	AFRC
T-34C (N865NA)	FDC	AFRC
X-56 (UAS)	FDC	AFRC
X-57 Maxwell	FDC	AFRC
S-3B (N601NA)	UAS – NAS	GRC
T-34C (N603NA, N608NA, N865NA)	UAS – NAS	GRC / AFRC
SR-22 (N501NA)	UAS – NAS	LaRC

The Transformative Aeronautics Concepts Program (TACP) cultivates multi-disciplinary, revolutionary concepts to enable aviation transformation. Although the scope of TACP is on narrowly focused research, the program provides flexibility for innovators to explore technology feasibility and provide the knowledge base for radical transformation. The program solicits and encourages revolutionary concepts, creates the environment for researchers to experiment with new ideas, performs ground and small-scale flight tests, allows failures and learns from them, and drives rapid turnover into potential future concepts. TACP currently only projects the following NASA aircraft requirements between FY 2019 and FY 2024:

Aircraft	Project	Center
DHC-6 (N607NA)	Transformational Tools & Tech.	GRC
T-34 (N865NA)	Transformational Tools & Tech.	AFRC

ARMD's overall strategic plan is to pursue long-term, cutting-edge research across all of its programs and projects so as to provide the foundation for future technology development. Its total aircraft funding for the out-years, as shown in Figure 51 below, is currently heavily concentrated on the Integrated Aviation Systems Program (IASP). Marking a change in ARMD's research priorities, the other three aeronautics programs, the Airspace Operations and Safety Program (AOSP), the Advanced Air Vehicles Program (AAVP), and the Transformative Aeronautics Concepts Program (TACP), all saw substantial budget reductions in the near term. In fact, the budget projections for these three programs do not contain any funding at all beyond FY 2021. While most of the ARMD budget identified below does not directly fund aircraft flight operations, they are indicators of flight test and aircraft requirements. ARMD funding will also continue to evolve as aircraft and aviation technologies mature to readiness levels that require flight testing.

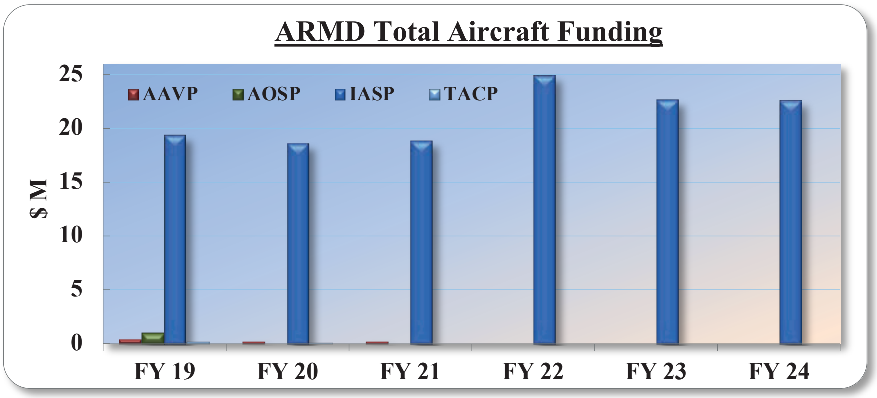

Figure 51 – ARMD Aircraft Funding

Science Mission Directorate (SMD)

NASA's Science Mission Directorate (SMD) supports flight missions that range from suborbital projects—including balloons, sounding rockets, and airplanes—to interplanetary probes and flagship observatories. All investigations and missions selected and flown by SMD correspond to stated Agency goals and strategic objectives. SMD funds two major scientific research flight programs in NASA – the Airborne Science Program (ASP) and the Stratospheric Observatory for Infrared Astronomy (SOFIA) Program. ASP supports manned and unmanned aircraft operations, including a range of NASA-owned and contracted aircraft, for the Agency's

Earth Science missions. These assets are used in worldwide campaigns to investigate extreme weather events, observe Earth system processes, obtain data for Earth modeling activities, and calibrate instruments flying aboard Earth science spacecraft. The SOFIA Program, on the other hand, operates a heavily modified Boeing 747SP, for astrophysics research.

As the world's premier aircraft program supporting Earth Science investigations, ASP collects and validates requirements in partnership with the three key stakeholders within the Earth Science community: (1) mission scientists and space flight mission managers, (2) engineers and developers of new instruments and (3) scientists in need of airborne observations. Near term requirements are gathered primarily through the online Science Operations Flight Request System (SOFRS), as well as inputs from mission science teams, conferences and scientific literature. The need for airborne observations related to priority SMD missions is tracked using a five-year plan, updated annually, and by frequent communications with the Earth Science Program Managers. ASP funding for aircraft operations, by aircraft, is projected in Figure 52 below.

While it is not apparent in Figure 52, the overall ASP funding commitment to aircraft operations is projected to decline from $23.5M in FY 2019 to $22.0M in FY 2021, with major aircraft programs, such as the WFF C-130, coming to completion. However, this sharply declining trend is somewhat deceptive as it also reflects the unique nature of airborne science that aircraft utilization commitments very much lags the project and program budgeting process and aircraft utilization are often only confirmed after programs and projects secure their budget and funding.

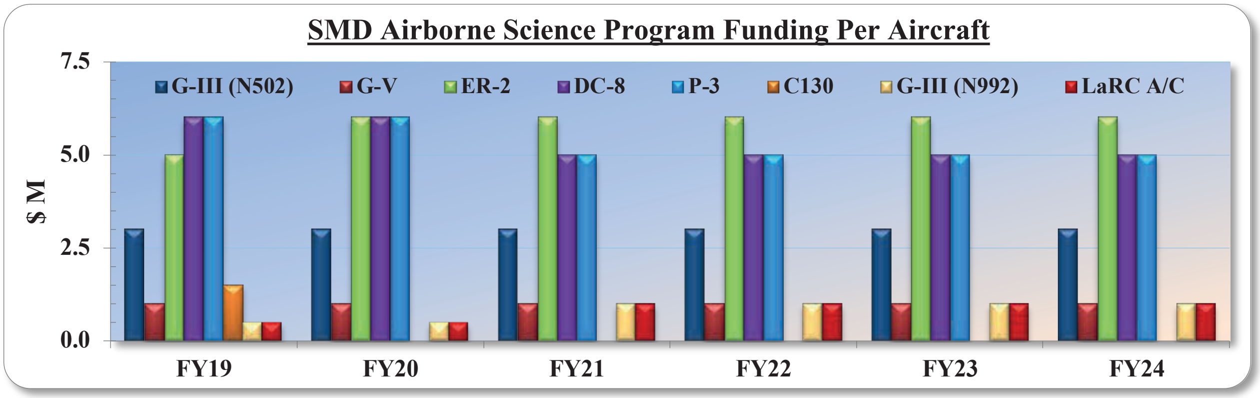

Figure 52 – Airborne Science Program Funding

Based on SMD inputs, NASA's aircraft operations community is well positioned to support the data-gathering needs of the science community to produce accurate guidance on environmental policy. NASA plays an important role in understanding the Earth System through the collection and analysis of data on ozone, carbon dioxide, fires, dust and aerosols, point source pollution, precipitation and storms, hurricanes, atmospheric trace gases, polar ice, and land changes. While much of this data comes from satellites, airborne systems play an essential role in gathering data at critical spatial and temporal points for understanding of geophysical processes and interpreting satellite information.

The SOFIA aircraft is the largest airborne observatory in the world and complements the Hubble, Spitzer, Herschel and James Webb space telescopes, as well as major Earth-based telescopes. It is capable of making observations that are impossible for even the largest and highest ground-based telescopes. Armstrong Flight Research Center operates the aircraft, while Ames Research Center manages SOFIA's science and mission operations in cooperation with the Universities Space Research Association (USRA) and the German SOFIA Institute (DSI). The triennial program review of the SOFIA Program in June 2019 funded the program for an additional three fiscal years beyond FY 2019. The exact operational budget level for the SOFIA program is still to be finalized as shown in Figure 53.

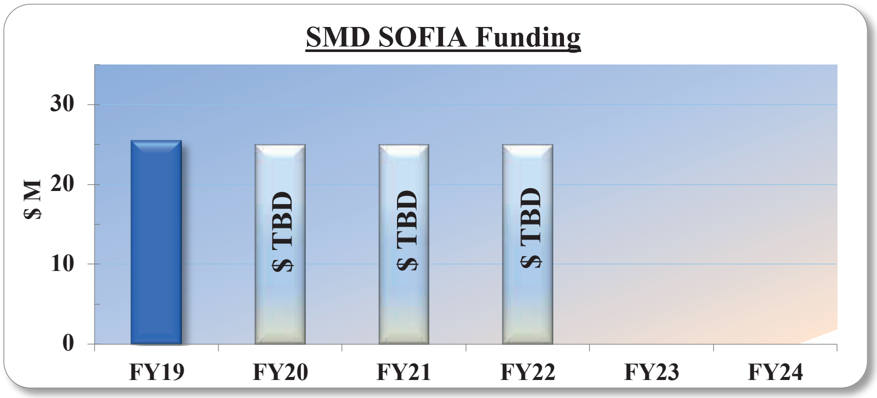

Figure 53 – SOFIA Program Total Funding

Factoring out the yet to be determined budget of the SOFIA program for the next three years, total SMD aircraft funding over the next six years is actually projected to be relatively stable from FY 2019 to FY 2024 at $22.0M a year, as shown in Figure 54. While the budget is stable, this projected ASP funding is significantly less than the $35.1M budget back in FY 2017. When the three-year budget for the SOFIA program is finalized, total projected SMD funding levels for aircraft operations will likely increase significantly for FY 2020 to FY 2022.

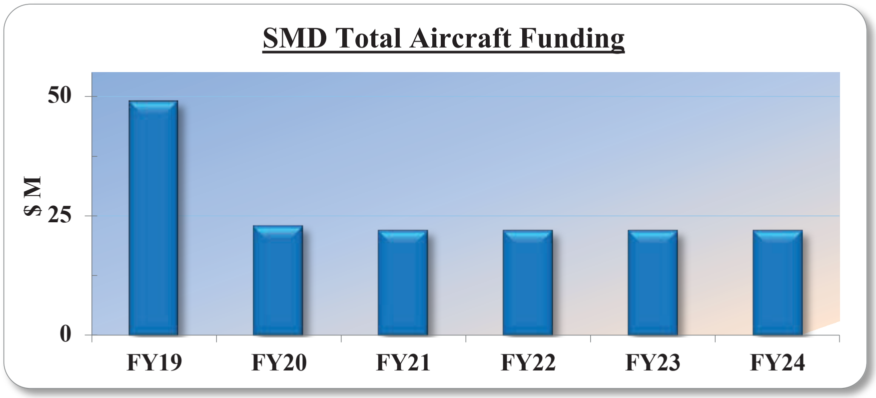

Figure 54 – SMD Total Aircraft Funding

Incorporating NASA Center inputs, SMD has funded aircraft requirements between FY 2019 and FY 2024 for the NASA aircraft listed below:

Aircraft	Program	Center
DC-8 (N817NA)	ASP	AFRC
ER-2 (N806NA, N809NA)	ASP	ARFC
G-III (N502NA)	ASP	ARFC
C-130 (N436NA)	ASP	GSFC (WFF)
P-3 (N426NA)	ASP	GSFC (WFF)
G-III (N992NA)	ASP	JSC
G-V (N95NA)	ASP	JSC
G-III (N520NA)	ASP	LaRC
B-200 (N528NA, N529NA)	ASP	LaRC
HU-25 (N525NA)	ASP	LaRC

Human Exploration and Operations Mission Directorate (HEOMD)

The use of aircraft in support of NASA's human space flight programs began with using high-performance jet aircraft to maintain the mental and manual skills of the test pilots selected as the first astronauts. Over the years, however, new NASA requirements have led to an expansion of the types of aircraft and missions supported by HEOMD, which can be summarized into three broad categories:

- Support crew training
- Support NASA's human space flight programs' aircraft and mission requirements
- Support Agency's human research and outreach programs

Space Flight Readiness Training (SFRT)

HEOMD requires the use of the high-performance T-38 jet aircraft, supplemented with the occasional use of the high-altitude WB-57 aircraft, in support of SFRT to maintain the mental and manual skills of astronauts as spacecraft crew members. SFRT develops the prioritization, discipline, communication, and crew coordination skills needed for high-stress, multi-task sortie operations, including launch and landing aboard any vehicle, rendezvous and docking, robotics and Extravehicular Activity (EVA) events, and emergency scenarios inside or outside a spacecraft. While these skills can be partly trained and exercised in simulators, an important component of achieving and maintaining these skills requires recurring training in an operational environment, defined as an environment where unpredictable or unforeseen events occur requiring real-time, critical decisions to be made which have real consequences and in which a wrong decision cannot be reversed, only the effects mitigated. Flights in high performance aircraft provide the desired operational environment. The Human Space Flight Office (HSFO) intends to only fund the use of T-38 aircraft from FY 2020 and out as depicted in Figure 55 on the next page.

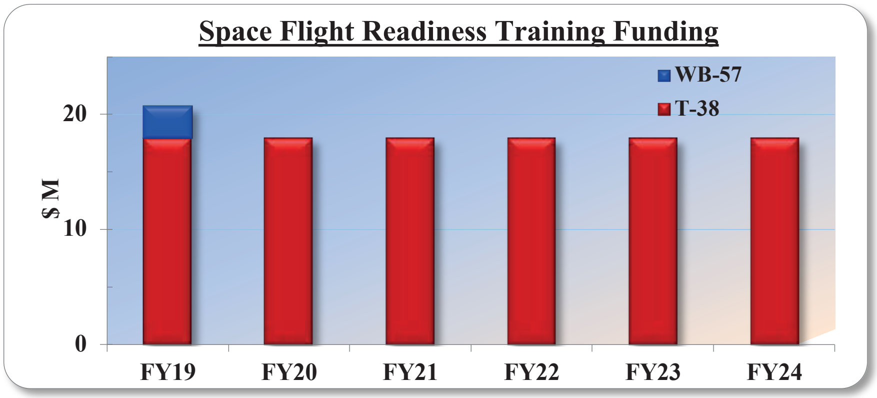

Figure 55 – Space Flight Readiness Training Funding

ISS Large Cargo Transport

The ISS Program entered into an agreement with the European Space Agency to transport all the major U.S. modules of ISS from their development sites to the launch site in Florida using Super Guppy aircraft. The Flight Crew Operations Directorate's (FCOD) expertise in safely planning, piloting, loading, and unloading unique cargo allowed NASA HEOMD to provide transportation flights at a competitive cost and also enabled NASA HEOMD to be a smart buyer for large cargo transportation needs. In addition, the FAA Reauthorization Act of 2018 also made it possible for NASA operate the Super Guppy and transport oversized spacecraft components for commercial space activities, making the aircraft indispensable to our nation's commercial space industry. As shown in Figure 56, HEOMD plans to fund Super Guppy at a level sufficient to ensure this unique asset is available for future outsized cargo missions. Figure 56, however, does not forecast the potential reimbursable activity to be funded by commercial customers.

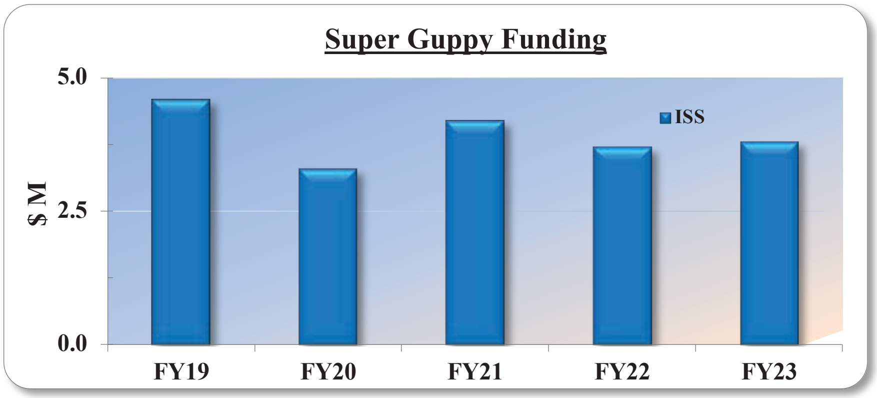

Figure 56 – Super Guppy Aircraft Funding

HEOMD's total aircraft budget for FY 2019 and the out-years is displayed in Figure 57 on the next page. HEOMD's aircraft requirements are projected to be stable, as the ripple effects from Shuttle Program termination have finally come to a close. With Human Space Flight to resume from U.S. soil, HEOMD aircraft requirements are expected to steadily increase beyond FY 2024.

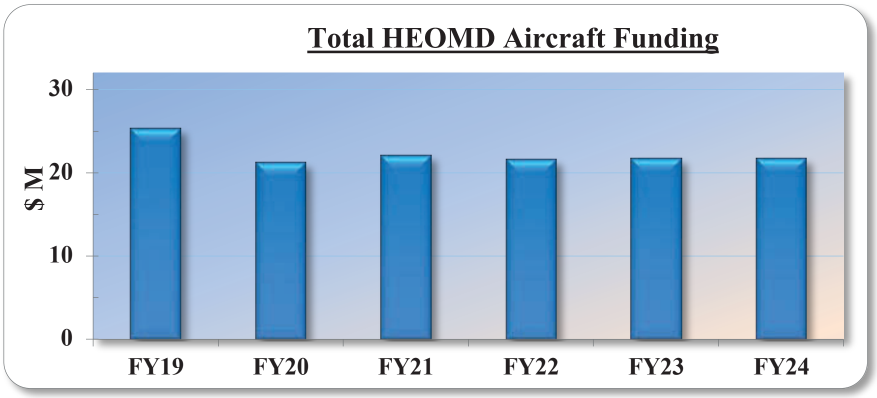

Figure 57 – Total HEOMD Aircraft Funding

HEOMD has current requirements for the following active NASA aircraft:

Aircraft	Program	Center
T-38 (20)	Space Flight Readiness Training	JSC
WB-57 (3)	Space Flight Readiness Training	JSC
G-III/G-V	Pilot Proficiency/Astronaut Transport	JSC
Super Guppy (1)	ISS Large Cargo Transport SSP/ISS	JSC

Center Funded Requirements

Several Centers have internal requirements for aircraft and these requirements are funded through CMAO at each Center. Some of these requirements are driven by the Center's mission focus, such as KSC, whose need for helicopter support for space launch/landing security is well established. Most of the Center aircraft requirements are driven by the need for cost effective pilot proficiency training aircraft with adequate avionics and instrument flight capabilities. These aircraft help maintain a cadre of highly experienced and proficient research and test pilots capable of safely and precisely piloting a variety of manned and unmanned research and test aircraft. The heavy lift, long-range research aircraft do not fly sufficiently and have long down times to accommodate the mission uploads, modifications, and maintenance activity to provide sufficient pilot proficiency flight time. These pilot proficiency trainers are also ideal for project support aircraft such as launch range surveillance and low speed chase including UAS chase.

Total FY 2019 CMAO funding budgeted for these aircraft is approximately $21.8M across the Agency. However, the $21.8M figure includes a one-time funding spike of $20.3M as Kennedy Space Center allocated funds to acquire replacement helicopters. Beyond FY 2019, CMAO funding for aircraft operations is expected to be a very minute contributor, around $1M to $2M annually, to the Agency's overall aircraft operations. The various aircraft to be supported via a combination of outyear CMAO funding, either in part or in total, are listed below:

Aircraft	Requirements	Center
Sierra (UAS)	Aircraft Operations Support	ARC
T-34	Pilot Proficiency	GRC
B-200	Pilot Proficiency/Range Support	GSFC (WFF)
Cessna 206	Aircraft Operations Support	GSFC (WFF)
UH-1H (3)	Launch Support/Security/Emergency Mgmt	KSC
B-200	Aircraft Operations Support	LaRC
G-III	Aircraft Operations Support	LaRC
HU-25 Falcon	Aircraft Operations Support	LaRC
LC-40	Pilot Proficiency/Research	LaRC
SR-22	Pilot Proficiency/Research	LaRC

IX. MISSION RISKS MANAGEMENT

For the last five years, the Aircraft Management Division had been identifying and elevating risks to Agency's missions that stemmed from possible weaknesses in NASA's aircraft operations. To date, AMD has identified six key aircraft operational risks that would impact the Agency's missions. They are (1) *Commercial Aviation Services (CAS) Oversight and Management;* (2) *NASA Aircraft Management Information Services (NAMIS) Funding;* (3) *Unmanned Aircraft Systems (UAS) Flight Operations Oversight*; (4) *Pilot Proficiency Training*; (5) *Aircraft Sustainability*; and (6) *Flight Operations Workload and Resource Imbalance*

Commercial Aviation Service (CAS) Oversight and Management

Safety oversight and management of Commercial Aviation Services, or CAS, remains a critical area of attention for the Aircraft Management Division (AMD) and the Inter-Center Aircraft Operations Panel (IAOP). As has been pointed out by the Federal Aviation Administration (FAA) and the National Transportation Safety Board (NTSB), safety of CAS flight operations is incumbent on the agency that has the mission responsibility. Figure 56 below also shows NASA's rapidly rising risk exposure to CAS as NASA increased its reliance on vendor-provided flight services in the last decade. There is no question that NASA needs more robust CAS operations oversight and surveillance programs to ensure the safety risks associated with CAS are adequately mitigated.

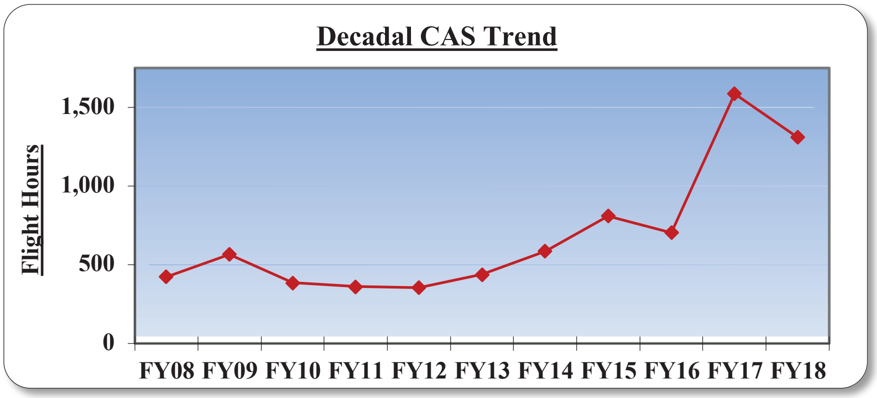

Figure 58 – NASA's CAS Exposure

Even with the recent insertion in NASA's Federal Acquisition Regulation Supplement to require all procurement of aircraft and aviation services be reviewed by an aircraft operations authority prior to contract award, there still have been instances of CAS use by NASA centers without appropriate review. Sometimes the uses of CAS only come to the attention of NASA's flight operations when safety issues arise, placing the Agency at great risk of loss of valuable property or lives, not to mention jeopardizing critical program and project milestones. It was not that long ago that NASA had two employees from Marshall Space Flight Center suffer injuries from in-flight decompression of a CAS flight that had not been reviewed by a NASA flight operations organization.

Past contractor quality and workmanship flaws also demonstrate the criticality of NASA's safety oversight role in the entire CAS acquisition process, but especially when it comes to contracted R&D flight services where NASA's unique missions require aircraft modifications or flights in atypical regimes. Contractor schedule slips in NASA aircraft modifications also impact program schedule, resulting in lost research opportunities. NASA's CAS oversight responsibility begins with the planning of the programs and projects, so that NASA's world-class performance and safety standards are built into the Requests for Proposals (RFPs). Then the Agency's flight operations must assist the programs and projects in selecting only qualified vendors that are capable of and committed to meeting NASA's high quality and safety standards. NASA's oversight continues with contract performance, often times with NASA instrument or personnel flying on board the contracted missions.

When NASA's people and equipment are exposed to flight risks, our aircraft operations managers have a responsibility to partner with the program and project managers and be the gatekeepers of NASA's safety requirements. To mitigate any safety risks of CAS flights, AMD and the IAOP have implemented higher standards, such as Federal Aviation Regulation (FAR) Part 135 requirements, in the recent update to NPR 7900 for the acquisition of CAS flight operations. In addition, to ensure that future acquisitions of CAS are adequately reviewed prior to contract award, AMD coordinated with NASA's Office of Procurement to update NASA Form 1707. The revised Form 1707 will require concurrences by Center Aircraft Operations for all CAS acquisitions prior to issuance of solicitation.

NASA Aircraft Management Information System (NAMIS)

NASA's Aircraft Management Information System (NAMIS) is an information technology (IT) system that is integral to NASA's aviation in the continuous mitigation of the multitude of risks from ever-evolving missions, volatile budgets, unforgiving schedules, diverse and unique aircraft configurations, and an aging fleet of aircraft. Given that funds for the NAMIS are always subject to budget pressures and may be greatly reduced or eliminated in the future, there is a potential that NAMIS may be degraded to the point where NASA would be forced to return to cumbersome manual aircraft management processes. This worst-case scenario would not only result in loss of missions, such as astronaut space flight readiness training, but may also allow an aircraft to be flown in an un-airworthy condition with unqualified pilots. Flight mishaps due to non-airworthy aircraft or pilot error can result in the loss of life and aircraft. The effort required to convince the Office of the Chief Information Officer's (OCIO) to not cut its FY 2019 NAMIS funding highlights the continual risk of inadequate NAMIS funding.

In addition to satisfying NASA's aircraft management requirements, NAMIS also discharges OMB Circular A-126 requirement for an agency aircraft information system. NAMIS not only allows Centers to manage aircraft maintenance, repair, and aircraft modification, but also tracks flight and maintenance crew qualification and currency, science instrument integration, component shelf life, and parts inventory for all configurations of NASA's 60+ active aircraft. Very simply, NAMIS ensures that only qualified, experienced, and current flight crews are flying airworthy aircraft that have been maintained to the high standards adhered to by NASA. The continual pressure to cut OCIO funding for NAMIS is NASA aviation community's number one operational risk.

Unmanned Aircraft Systems (UAS) Flight Operations Oversight

It was only in FY 2007 when the then Dryden Flight Research Center (DFRC) first began to operate the Ikhana UAS, the only reported UAS in the Agency at the time. Over the last decade, the Agency's reported UAS inventory had grown to over 250 by FY 2018. With the exception of the Glenn Research Center, these UAS were operated across all NASA centers. Like NASA's manned aircraft operations, NASA's UAS flew in both restricted airspace and the National Airspace, with flights of the smaller UAS typically lasting less than 15 minutes.

Most of NASA's 250+ UAS are very small, weighing much less than 55 lbs, with top speeds well below 70 knots. These small UAS do not meet the Federal Aircraft requirements for reporting to the General Services Administration (GSA), which set the UAS reporting criterion at each federal agency's Capital Asset threshold. In fact, NASA only operates three large UAS, the Sierra at Ames and two Global Hawk UAS at Armstrong, that meet the Federal Aircraft reporting requirement.

While UAS are defined as aircraft by the FAA, UAS operations require considerably different skill sets than manned aircraft flights, as well as significant amounts of time and resources to operate effectively and safely. These UAS assets not only require different operator/pilot training and vehicle maintenance, their oversight also requires NASA to stay abreast of developing FAA policies and regulations regarding the integration of UAS into the National Airspace. Just as rules and regulation for manned aviation were developed over time, the advent of UAS also foreshadows additional federal policies regarding their use, such as he Presidential Memorandum issued in February 2015 requiring federal agencies to safeguard privacy, civil rights, and civil liberties in the domestic use of UAS.

Just as with flights of manned aircraft, the operation of UAS requires expertise in aircraft airworthiness, certification, range safety, and airspace navigation. However, the level of oversight for NASA's UAS is also scaled according to the risks associated with their ownership and operation. Long duration operation of Armstrong' Global Hawk UAS in large swaths of the national and international airspace requires arduous coordination with other agencies, such as the FAA, and international government organizations. The infrastructure required to perform these types of missions is complex and intricate. On the other end of the scale, LaRC is designing and flight testing small UAS in controlled environments so that we may one day fly UAS in the thin atmosphere of Mars. Use of small Commercial-off-the-Shelf (COTS) UAS for a variety of Agency functions, such as aerial photography, is another example of the rapidly expanding use of UAS technology in NASA. In between the very large and the very small, ARC operates the medium-sized Sierra UAS mainly for aeronautics research, but also for Earth Science. The operations of these diverse UAS involve varying operational risks and require different levels of management and safety oversight.

Small UAS (sUAS) in particular are inexpensive to acquire and are operated by people that typically do not know that small UAS are considered as aircraft and are unaware of existing and emerging FAA and federal regulations on UAS. The operators of these sUAS quite often are not knowledgeable of the safety oversight required for aircraft, the risks UAS bring to NASA, and the property management rules for all UAS. In a 2017 audit report, NASA's Office of Inspector General (OIG), specifically pointed out gaps in NASA's implementation of UAS operational oversight and inventory management requirements.

The assorted UAS management and oversight challenges are being addressed in a number of ways by NASA's aviation community. The Inter-Center Aircraft Operations Panel (IAOP) has chartered a UAS Working Group comprising of representatives from all Centers and Mission Directorates. This UAS Working Group's goal is to improve Agency-wide communication and coordination of UAS information, promote integration between NASA and other agencies, improve customer interfaces, mitigate risk to mission and optimize safety. ARMD and AMD have taken the lead on a FAA/DOD committee, whose Congressional mandate is to find ways to seamlessly integrate UAS into the National Airspace System (NAS). AMD has also coordinated with NASA's Office of Procurement to integrate UAS operational safety oversight as a requirement when contracting officers procure sUAS. With the support of NASA Safety Center, AMD conducted an online outreach session to reach out to all potential UAS users in the Agency. Building on the policy that required Center management to establish acquisition and safety processes for UAS below reporting threshold, AMD is also strengthening UAS acquisition and disposition guidelines to address the recommendations from the 2017 OIG audit report. However, as the use of UAS becomes ever more ubiquitous across NASA, UAS oversight requirements will only increase.

Pilot Proficiency Training

NASA aircraft are unique and complex, and are operated by individuals that need to maintain high levels of piloting proficiency in diverse types of aircraft. NASA has sustained several flight mishaps and close calls within the last decade that have come dangerously close to the loss of an aircraft or significant material damage. The historical records indicate that on average about one major aircraft mishap occurs every five years. Most were due to pilot error while the remainder has been the result of maintenance problems or material failures. Increasingly, due to budget constraints across the agency, pilots are at increasing risk of not maintaining a sufficient level of proficiency in their flying skills.

To mitigate the pilot proficiency training risk, AMD maintains a minimal simulator training budget, as well as an Agency-wide simulator contract to support center aircraft operations. However, Programs and Centers must continue to fund robust aviation training programs to mitigate the risks associated with the lack of pilot proficiency. Pilots may achieve proficiency benefits from flying multiple aircraft and through the use of flight simulators, where available. Each Center's needs are unique based on the number and the complexity of their aircraft, frequency of missions, and other factors. AMD has continued to work closely with Centers, especially those with smaller scales of flight operations, to identify and fund simulator training to mitigate this risk.

Aircraft Sustainability

NASA operates aircraft comprised of unique configurations, many of which were acquired from DOD's inventory of retired aircraft. These aircraft require a substantial investment in maintenance expertise and repair parts to assure a high standard of airworthiness and mission readiness. Moreover, many of the required parts are either no longer in production or are a one-of-a-kind NASA configuration. Examples of unique NASA research aircraft include the Wallops Flight Facility's P-3B, Johnson Space Center's Super Guppy and WB-57, Armstrong Flight Research Center's DC-8, ER-2, and SOFIA, and Glenn Research Center's S-3B aircraft. These Centers must sustain a robust maintenance program for these unique older airframes. On a continuing basis, Centers must maintain these aircraft to the highest material standards to mitigate the risks associated with older and one-of-a-kind aircraft. Centers have to pay particular attention to employ experienced human resources for unique aircraft maintenance, monitor the trends in parts failure and availability, and take full advantage of DOD parts inventories while they can.

It takes more than just a robust maintenance program to sustain NASA's aircraft operations, however. From its repeated visits to NASA Centers and Headquarter, the Aerospace Safety Advisory Panel (ASAP) observed that deferred maintenance, modification, and upgrading of basic NASA aircraft infrastructure deserved and needed higher prioritization. The ASAP recently concluded that NASA accomplishments are noteworthy, but the Agency nevertheless should fund a prompt and thorough assessment of its aging fixed-wing aircraft fleet and aircraft support facilities. To answer the ASAP recommendation and to address the sustainability question, the Aircraft Management Division commissioned an independent assessment of the Agency's aging fleet of aircraft. The survey largely validated NASA's capabilities and the processes that the aircraft operations community put in place based on years of accumulated knowledge and experience to sustain the Agency's fleet of aging, but unique aircraft. In order to safely operate its aging aircraft, NASA must continue to incorporate safety upgrades, such as Traffic Collision Avoidance Systems (TCAS), Terrain Avoidance Warning Systems (TAWS), and Automatic Dependence Surveillance-Broadcast (ADS-B) as recommended by the ASAP.

Flight Operations Workload and Resource Imbalance

While NASA aircraft operate out of seven different Centers, the workload for aviation is not evenly distributed. Given that resources for the aircraft operations at the centers may be reduced due to programmatic changes or budgetary factors, there is a possibility that aircraft operations personnel may be reduced to levels that would leave flight operations inadequately staffed, thereby reducing both operational capabilities and safety margins. As workloads climb in the face of budgetary and personnel limitations, NASA must operate its aircraft more efficiently, with more streamlined processes, but without sacrificing safety.

While a specific minimum size for a flight operation has not been defined, it depends upon, among other factors, the age, number and complexity of the aircraft, the tempo and range of flight operations, and the expertise of the assigned crew and technicians. The functional disciplines required by NPD 7900 are: a Chief of Flight Operations, an Aviation Safety Officer, a Chief of Maintenance, a Chief of Engineering (when aircraft modifications are routine), and a Chief of Quality Assurance. Due to commonly confronted resource constraints, aircraft operations may not be able to fully staff these positions at the required level and experience. Flight mishaps due to insufficient oversight of maintenance and flight activities can cause death or loss of aircraft.

Large aircraft operations are not immune to work load imbalance issues. Recent IAOP Reviews and Safety Culture Surveys of agency aircraft operations have identified an evolving risk where aircraft operations workload, flight tempo, and resources were out of balance. Surges in flight research campaigns and NASA's self-imposed civil service hiring ceilings only compound the problem. While contractor support of NASA flight operations can be augmented relatively easily, the risk of contract profits influencing mission safety decisions also increases. The workload and resource imbalance challenge has resulted in the IAOP Reviews specifically adding a step to assess staffing adequacy at the centers' flight operation organizations.

Fiscal Year 2018
Year End Active Aircraft Inventory

FY 2018 Annual NASA Aircraft Report
June 2019
Appendix 1 – Fiscal Year 2018 Year End Aircraft Inventory

NASA FY 2018 Year End Active Aircraft Inventory

Location	Aircraft	Primary Utility Designation	Qty	PPES Aircraft Value
ARC	Sierra UAS #2	R&D	1	$ 499,000
Subtotal ARC			**1**	**$ 499,000**
AFRC	B-200 (N7NA & N801NA)	PS / R&D	2	$ 3,126,280
	C-20A (Gulfstream G-III: N502NA)	R&D	1	$ 22,200,000
	DC-8 (N817NA)	R&D	1	$ 21,383,925
	ER-2 (N806NA & N809NA)	R&D	2	$ 25,890,033
	F-15B (N836NA)	R&D	1	$ 40,000,000
	F-15D (N884NA & N897NA)	PS / R&D	2	$ 29,900,000
	F/A-18 (N843NA, N846NA, & N850NA)	PS	3	$ 71,100,000
	Global Hawk (N872NA & N874NA activated for reimbursable project)	R&D	2	$ 40,000,000
	Gulfstream G-III (N804NA)	R&D	1	$ 22,200,000
	Gulfstream G-III (N808NA)	PS	1	$ 1,250,000
	Ikhana UAS (N870NA) (Placed into inactive status)	R&D	-	$ -
	SOFIA (N747NA)	R&D	1	$ 12,200,000
	T-34C (N865NA)	PS	1	$ 500,000
	TG-14 (N856NA))	PS	1	$ 75,000
	X-56 UAS	R&D	1	$ 1,350,000
Subtotal AFRC			**20**	**$ 291,175,238**
GRC	DHC-6 (N607NA)	R&D	1	$ 256,422
	S-3B (N601NA)	R&D	1	$ 26,559,998
	T-34C (N605NA & N608NA)	PS	2	$ 2,000,000
Subtotal GRC			**4**	**$ 28,816,420**
GSFC	B-200 (N8NA)	PS	1	$ 1,399,544
	C-23 (N430NA)	R&D	1	$ 7,422,158
	C-130 (N436NA) (N439NA placed into inactive status)	R&D	1	$ 11,759,427
	P-3 (N426NA)	R&D	1	$ 1,582,458
Subtotal GSFC			**4**	**$ 20,581,129**
JSC	B-377 Super Guppy (N941NA)	PS	1	$ 6,000,000
	Gulfstream G-III (N992NA)	PS / R&D	1	$ 10,143,925
	Gulfstream G-V (N95NA)	PS / R&D	1	$ 12,900,000
	T-38 Astronaut Trainer	PS	20	$ 14,487,711
	WB57 (N926NA, N927NA, & N928NA)	R&D	3	$ 25,206,040
Subtotal JSC			**26**	**$ 68,737,676**
KSC	UH-1H (N416NA, N418NA, & N419NA)	PS	3	$ 9,000,000
Subtotal KSC			**3**	**$ 9,000,000**
LaRC	B-200 (N528NA & N529NA)	PS	2	$ 5,159,540
	Cessna C206 (N504NA)	R&D	1	$ 400,616
	Cirrus SR-22 (N501NA)	R&D	1	$ 341,954
	Gulfstream G-III (N520NA) Missionization underway.	R&D	1	$ 16,000,000
	HU-25 (N525NA) To be replaced by N520NA.	R&D	1	$ 5,219,488
	LC40 (N507NA)	R&D	1	$ 419,135
Subtotal LaRC			**7**	**$ 27,540,733**
Total NASA			**65**	**$ 446,350,196**

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NASA Aircraft Information Sheets

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Aircraft Information Sheet # 1

Armstrong Flight Research Center
Ratheon Be-200 Super King Air Program Support Aircraft

General Characteristics	Twin engine pressurized turboprop aircraft. Typical seating is for 6-8 passengers.

Length (ft):	43.8	*Range/Endurance:*	1490 NM
Span (ft):	54.5	*Cruise Speed (Kts):*	272
Max Weight (lb):	12,500	*Altitude (ft):*	30,000
Payload (lb):	1,850		

Utilization

Current Role:	Program Support, Pilot Proficiency, Pax Transport
Quantity:	2
Total Hours FY18:	220.5
Aircraft Age:	33~36
Suitability:	Excellent. Good Balance for Mission. Economical.
Estimated Service Life:	15+ years
Future Role(s):	Same
Servicibility Expectation:	Excellent
Projected Utilization:	250

Replacement Aircraft Requirements

Replace When:	Not Recommended
Replacement Justification:	N/A
Replacement Criteria:	N/A
Recommed Replacement:	N/A

Aircraft Information Sheet # 2

Armstrong Flight Research Center
C-20 (Gulfstream Aerospace G-III) Research Aircraft

General Characteristics

Large twin-engine, 12-passenger business jet modified for flight research.

Length (ft):	83.2	*Range/Endurance:*	3700 NM
Span (ft):	77.8	*Cruise Speed (Kts):*	459
Max Weight (lb):	69,700	*Altitude (ft):*	45,000
Payload (lb):	4,500		

Utilization

Current Role:	Flight Research, Science Mission Pods w/ Extremely Accurate, Repeatable Autopilot.
Quantity:	1
Total Hours FY18:	263.1
Aircraft Age:	35
Suitability:	Excellent. Economical for Mission.
Estimated Service Life:	10 years with suitable engine solution
Future Role(s):	Same
Servicibility Expectation:	Fair
Projected Utilization:	300

Replacement Aircraft Requirements

Replace When:	When Engines Become Unsupportable Due to Noise Requirements.
Replacement Justification:	Noise Requirements
Replacement Criteria:	Mid-Size, Fuel Efficient.
Recommed Replacement:	G-V or Global Express

Aircraft Information Sheet # 3

Armstrong Flight Research Center
Boeing (Douglas) DC-8 Earth Science Research Aircraft

General Characteristics

Versatile airborne science platform based on the 4-engine DC-8 transport airliner. Re-engined with fuel-eficient DFM-56 engines.

Length (ft):	157	*Range/Endurance:*	5,400 NM
Span (ft):	148.5	*Cruise Speed (Kts):*	490
Max Weight (lb):	350,000	*Altitude (ft):*	41,000
Payload (lb):	30,000		

Utilization

Current Role:	Airborne Science Research Platform
Quantity:	1
Total Hours FY18:	410.2
Aircraft Age:	32
Suitability:	Excellent
Estimated Service Life:	10 years
Future Role(s):	Same
Servicibility Expectation:	Good
Projected Utilization:	500

Replacement Aircraft Requirements

Replace When:	TBD
Replacement Justification:	Supportability
Replacement Criteria:	Large Cabin, Mid Altitude, Long Range/Endurance
Recommed Replacement:	Must Meet Research Requirement

Aircraft Information Sheet # 4

Armstrong Flight Research Center
Lockheed-Martin ER-2 High Altitude Research Aircraft

General Characteristics

High altitude research aircraft derived from the U-2 military reconnaissance aircraft.

Length (ft):	62.1	*Range/Endurance:*	6,000 NM
Span (ft):	103.3	*Cruise Speed (Kts):*	410
Max Weight (lb):	40,000	*Altitude (ft):*	70,000+
Payload (lb):	2,600		

Utilization

Current Role:	High Altitude Research for Earth Science & Remote Sensing
Quantity:	2
Total Hours FY18:	29.5
Aircraft Age:	30~37
Suitability:	Excellent
Estimated Service Life:	>20 years
Future Role(s):	Same
Servicibility Expectation:	Good
Projected Utilization:	300

Replacement Aircraft Requirements

Replace When:	When No Longer Supportable
Replacement Justification:	Supportability
Replacement Criteria:	High Altitude; Long Endurance
Recommed Replacement:	Possible Global Hawk or similar UAV

Aircraft Information Sheet # 5

Armstrong Flight Research Center
Boeing F-15B/D Research & Program Support Aircraft

General Characteristics

Modified supersonic tactical fighter aircraft.

Length (ft):	64	*Range/Endurance:*	Refuelable
Span (ft):	43	*Cruise Speed (Kts):*	Mach 2+
Max Weight (lb):	42,000	*Altitude (ft):*	60,000
Payload (lb):			

Utilization

Current Role:	High Performance Flight Research and Safety Chase
Quantity:	3
Total Hours FY18:	77.7
Aircraft Age:	39~44
Suitability:	Excellent
Estimated Service Life:	10+ years
Future Role(s):	Same
Servicibility Expectation:	B Model Becoming Difficult to Support & Maintain.
Projected Utilization:	75

Replacement Aircraft Requirements

Replace When:	N836 Needs to Be Replaced Soon.
Replacement Justification:	Supportability
Replacement Criteria:	High Performance, Supersonic Tactical Fighter.
Recommed Replacement:	Working to Replace Both Aircraft with Excess USAF F-15D.

Aircraft Information Sheet # 6

Armstrong Flight Research Center
Boeing F/A-18A/B Program Support Aircraft

General Characteristics

High performance supersonic tactical fighter/attack aircraft.

Length (ft):	56	*Range/Endurance:*	1546 NM
Span (ft):	40.3	*Cruise Speed (Kts):*	Mach 1.7+
Max Weight (lb):	23,400	*Altitude (ft):*	50,000+
Payload (lb):			

Utilization

Current Role:	Program Support: Safety Chase, Aerial Photo, Pilot Proficiency R&D: High Performance Flight Research
Quantity:	3
Total Hours FY18:	148.9
Aircraft Age:	38~42
Suitability:	Excellent
Estimated Service Life:	10+ years
Future Role(s):	Same
Servicibility Expectation:	Good. Acquired Free F404 Engine Cores from F-117 Shutdown.
Projected Utilization:	150

Replacement Aircraft Requirements

Replace When:	N852 Becoming Unsupportable and Needs to be Replaced ASAP.
Replacement Justification:	Supportability and Prototype Fuel Heat Limitation.
Replacement Criteria:	> M 1.8 and Production Representative for Supportability.
Recommed Replacement:	F-15D for N852 Only.

Aircraft Information Sheet # 7

Armstrong Flight Research Center
Gulfstream Aerospace G-III Research & Program Support Aircraft

General Characteristics

Twin-engine, long range, 12-passenger business jet.

Length (ft):	83.1	*Range/Endurance:*	3,700 NM
Span (ft):	77.8	*Cruise Speed (Kts):*	459
Max Weight (lb):	69,700	*Altitude (ft):*	45,000
Payload (lb):	4,500		

Utilization

Current Role:	Aeronautics Research and Proficiency Training.
Quantity:	2
Total Hours FY18:	166.8
Aircraft Age:	34~36
Suitability:	Well Suited
Estimated Service Life:	15+ years
Future Role(s):	Aeronautics Research, Pilot Proficiency Training, & Pax Transport.
Servicibility Expectation:	Good
Projected Utilization:	200

Replacement Aircraft Requirements

Replace When:	N/A
Replacement Justification:	N/A
Replacement Criteria:	N/A
Recommed Replacement:	N/A

Aircraft Information Sheet # 8

Armstrong Flight Research Center
General Atomics Predator B (Ikhana) Unmanned Aerial Vehicle

General Characteristics

Single engine, push-propeller, long-endurance Unmanned Aerial System (UAS).

Length (ft):	36	*Range/Endurance:*	3,500 NM
Span (ft):	66	*Cruise Speed (Kts):*	170
Max Weight (lb):	10,500	*Altitude (ft):*	40,000+
Payload (lb):	2,000+		

Utilization

Current Role:	Earth Science flight research; Flight Control Research; Sense and Avoid Collision Avoidance R&D.
Quantity:	1
Total Hours FY18:	23.9
Aircraft Age:	12
Suitability:	Excellent
Estimated Service Life:	15+ years
Future Role(s):	None
Servicibility Expectation:	Excellent
Projected Utilization:	0

Replacement Aircraft Requirements

Replace When:	Disposition in the next year.
Replacement Justification:	N/A
Replacement Criteria:	N/A
Recommed Replacement:	N/A

Aircraft Information Sheet # 9

Armstrong Flight Research Center
Northrop Grumman RQ-4 Global Hawk

General Characteristics	Long Endurance Unmanned Aerial System (UAS)			
	Length (ft):	44	*Range/Endurance:*	14K NM / 42 hrs
	Span (ft):	116	*Cruise Speed (Kts):*	343
	Max Weight (lb):	25,600	*Altitude (ft):*	65,000
	Payload (lb):	1,900		

Utilization	*Current Role:*	Earth Science flight research
	Quantity:	2
	Total Hours FY18:	41.5
	Aircraft Age:	14
	Suitability:	Excellent
	Estimated Service Life:	15+ years
	Future Role(s):	Reimbursable Research
	Servicibility Expectation:	Excellent
	Projected Utilization:	150

Replacement Aircraft Requirements	*Replace When:*	N/A
	Replacement Justification:	N/A
	Replacement Criteria:	N/A
	Recommed Replacement:	N/A

Aircraft Information Sheet # 10

Armstrong Flight Research Center
Stratospheric Observatory for Infrared Astronomy (SOFIA) Research Aircraft

General Characteristics

Modified Boeing 747SP carrying a 9-ft diameter, 24-ton telescope for night-time infrared astronomy.

Length (ft):	185	*Range/Endurance:*	7,650 NM
Span (ft):	196	*Cruise Speed (Kts):*	535
Max Weight (lb):	670,000	*Altitude (ft):*	40,000+
Payload (lb):	-		

Utilization

Current Role:	High Altitude Infrared Astronomy, Heavy Aircraft Training
Quantity:	1
Total Hours FY18:	687.0
Aircraft Age:	42
Suitability:	Good
Estimated Service Life:	15 years
Future Role(s):	Same
Servicibility Expectation:	Satisfactory
Projected Utilization:	700

Replacement Aircraft Requirements

Replace When:	N/A
Replacement Justification:	N/A
Replacement Criteria:	N/A
Recommed Replacement:	N/A

Aircraft Information Sheet # 11

Armstrong Flight Research Center
Beech T-34C Mentor Program Support Aircraft

General Characteristics	Un-pressurized, two-place, tandem cockpit, low-wing, single-engine, turbo-prop monoplane.		
Length (ft):	28.5	*Range/Endurance:*	~600 NM
Span (ft):	33.3	*Cruise Speed (Kts):*	223
Max Weight (lb):	4,400	*Altitude (ft):*	25,000
Payload (lb):	-		

Utilization

Current Role:	Safety Chase; Pilot Training; Aerial Photography; Low Speed Flight Research.
Quantity:	1
Total Hours FY18:	138.7
Aircraft Age:	41
Suitability:	Adquate
Estimated Service Life:	15 years
Future Role(s):	Same
Servicibility Expectation:	Good
Projected Utilization:	150

Replacement Aircraft Requirements

Replace When:	N/A
Replacement Justification:	N/A
Replacement Criteria:	N/A
Recommed Replacement:	N/A

Aircraft Information Sheet # 12

Armstrong Flight Research Center
Aeromot TG-14 Power Glider Program Support Aircraft

General Characteristics

Experimental UAS to support Fundamental Aeronautics Research.

Length (ft):	7.5	*Range/Endurance:*	
Span (ft):	28	*Cruise Speed (Kts):*	150
Max Weight (lb):	480	*Altitude (ft):*	10,000
Payload (lb):	-		

Utilization

Current Role:	To advance aeroservoelastic technology through flight research.
Quantity:	1
Total Hours FY18:	8.9
Aircraft Age:	6
Suitability:	Good
Estimated Service Life:	5+ years
Future Role(s):	Same
Servicibility Expectation:	Good
Projected Utilization:	20

Replacement Aircraft Requirements

Replace When:	
Replacement Justification:	
Replacement Criteria:	
Recommed Replacement:	

Aircraft Information Sheet # 13

Armstrong Flight Research Center
Aeromot TG-14 Power Glider Program Support Aircraft

General Characteristics	Motroized glider.		
Length (ft):	26.5	*Range/Endurance:*	400 NM / 5 hrs
Span (ft):	57.3	*Cruise Speed (Kts):*	111
Max Weight (lb):	1,775	*Altitude (ft):*	20,000
Payload (lb):	-		

Utilization	*Current Role:*	Low Speed Flight Research. UAS Surrogate and Safety Chase.
	Quantity:	1
	Total Hours FY18:	71.1
	Aircraft Age:	15
	Suitability:	Good
	Estimated Service Life:	20+ years
	Future Role(s):	Same
	Servicibility Expectation:	Good
	Projected Utilization:	50

Replacement Aircraft Requirements	*Replace When:*	
	Replacement Justification:	
	Replacement Criteria:	
	Recommed Replacement:	

Aircraft Information Sheet # 14

Ames Research Center
Scientific Instrumentation Evaluation Remote Research Aircraft (SIERRA)

General Characteristics

Medium range UAS. Manual takeoff and land; Piccolo autopilot for GCS operation.

Length (ft):	11.8	*Range/Endurance:*	600 nm
Span (ft):	20	*Cruise Speed (Kts):*	55
Max Weight (lb):	350	*Altitude (ft):*	10,000
Payload (lb):	50+		

Utilization

Current Role:	Earth science missions. Capture multispectral imagery of land, sea and ice.
Quantity:	1
Total Hours FY18:	28.3
Aircraft Age:	1
Suitability:	Excellent
Estimated Service Life:	10+ years
Future Role(s):	Same
Servicibility Expectation:	Excellent
Projected Utilization:	75

Replacement Aircraft Requirements

Replace When:	N/A
Replacement Justification:	N/A
Replacement Criteria:	N/A
Recommed Replacement:	N/A

Aircraft Information Sheet # 15

Glenn Research Center
DeHavilland DHC-6 "Twin Otter" Research Aircraft

General Characteristics

Twin-engine, fixed landing gear, non-pressurized commuter aircraft, modified for flight research.

Length (ft):	51.9	*Range/Endurance:*	400 NM
Span (ft):	65	*Cruise Speed (Kts):*	150
Max Weight (lb):	11,000	*Altitude (ft):*	12,500+
Payload (lb):	3,600		

Utilization

Current Role:	Research
Quantity:	1
Total Hours FY18:	97.5
Aircraft Age:	53
Suitability:	Good
Estimated Service Life:	10+ years
Future Role(s):	Same
Servicibility Expectation:	Good
Projected Utilization:	100

Replacement Aircraft Requirements

Replace When:	TBD
Replacement Justification:	N/A
Replacement Criteria:	N/A
Recommed Replacement:	N/A

Aircraft Information Sheet # 16

Glenn Research Center
Lockheed Martin S-3B Viking Research Aircraft

General Characteristics	US Navy all weather, carrier based, S-3B aircraft modified for icing research.

Length (ft):	53	*Range/Endurance:*	2,300 NM
Span (ft):	69	*Cruise Speed (Kts):*	450
Max Weight (lb):	52,500	*Altitude (ft):*	40,000
Payload (lb):	15,000		

Utilization	*Current Role:*	Icing Research, Earth Science, & Reimbursable Projects.
	Quantity:	1
	Total Hours FY18:	36.3
	Aircraft Age:	39
	Suitability:	Excellent
	Estimated Service Life:	5+ years
	Future Role(s):	To be Retired
	Servicibility Expectation:	Becoming Challenging to Sustain
	Projected Utilization:	50

Replacement Aircraft Requirements	*Replace When:*	N/A
	Replacement Justification:	N/A
	Replacement Criteria:	Supportability
	Recommed Replacement:	Must Meet Research Requirements

Aircraft Information Sheet # 17

Glenn Research Center
Beechcraft T-34C TurboMentor Aircraft

General Characteristics

Program Support aircraft used for aerial photography, pilot proficiency training, and safety chase for slower research aircraft.

Length (ft):	28	*Range/Endurance:*	750 NM
Span (ft):	33	*Cruise Speed (Kts):*	214
Max Weight (lb):	4,300	*Altitude (ft):*	25,000
Payload (lb):	500		

Utilization

Current Role:	Pilot Proficiency, UAS Safety Chase (at WFF).
Quantity:	2
Total Hours FY18:	68.2
Aircraft Age:	39~40
Suitability:	Adequate
Estimated Service Life:	15 years
Future Role(s):	Same
Servicibility Expectation:	Good
Projected Utilization:	100

Replacement Aircraft Requirements

Replace When:	N/A
Replacement Justification:	N/A
Replacement Criteria:	N/A
Recommed Replacement:	N/A

Aircraft Information Sheet # 18

Johnson Space Center
Aero Spacelines B-377SG "Super Guppy" Support Aircraft

General Characteristics

Boeing 377 modified for oversized cargo for the International Space Station.

Length (ft):	144	*Range/Endurance:*	1,700 NM
Span (ft):	156	*Cruise Speed (Kts):*	250
Max Weight (lb):	170,000	*Altitude (ft):*	25,000
Payload (lb):	52,500		

Utilization

Current Role:	Oversized Cargo Transport for International Space Station and Reimbursable Customers.
Quantity:	1
Total Hours FY18:	72.1
Aircraft Age:	55
Suitability:	Well Suited
Estimated Service Life:	10+ years
Future Role(s):	Same
Servicibility Expectation:	Good
Projected Utilization:	125

Replacement Aircraft Requirements

Replace When:	N/A
Replacement Justification:	N/A
Replacement Criteria:	N/A
Recommed Replacement:	N/A

Aircraft Information Sheet # 19

Johnson Space Center
Gulfstream Aerospace G-III Research Aircraft

General Characteristics

Twin-engine, long range, 12-passenger business jet.

Length (ft):	83.1	*Range/Endurance:*	3,700 NM
Span (ft):	77.8	*Cruise Speed (Kts):*	459
Max Weight (lb):	69,700	*Altitude (ft):*	45,000
Payload (lb):	4,500		

Utilization

Current Role:	Direct Astronaut Return from Kazakhstan and Airborne Science Research.
Quantity:	1
Total Hours FY18:	267.0
Aircraft Age:	38
Suitability:	Not Stage III Compliant
Estimated Service Life:	10+
Future Role(s):	Airborne Science Research and Back Up for Direct Astronaut Return
Servicibility Expectation:	Fair
Projected Utilization:	300

Replacement Aircraft Requirements

Replace When:	N/A
Replacement Justification:	N/A
Replacement Criteria:	N/A
Recommed Replacement:	N/A

Aircraft Information Sheet # 20

Johnson Space Center
Gulfstream Aerospace G-V Program Support Aircraft

General Characteristics	Twin-engine, long range, 12-passenger business jet.		
Length (ft):	96.4	*Range/Endurance:*	5,500 NM / 15 Hrs
Span (ft):	93.45	*Cruise Speed (Kts):*	Mach 0.83
Max Weight (lb):	90,500	*Altitude (ft):*	51,000
Payload (lb):	8,100		

Utilization	*Current Role:*	Direct Astronaut Return from Kazakhstan, Airborne Science Research, and Pax Transport.
	Quantity:	1
	Total Hours FY18:	146.8
	Aircraft Age:	17
	Suitability:	Well suited.
	Estimated Service Life:	20+
	Future Role(s):	Direct Astronaut Return Mission and Airborne Science Research.
	Servicibility Expectation:	Fair
	Projected Utilization:	300

Replacement Aircraft Requirements	*Replace When:*	N/A
	Replacement Justification:	N/A
	Replacement Criteria:	N/A
	Recommed Replacement:	N/A

Aircraft Information Sheet # 21

Johnson Space Center
Northrup-Grumman T-38N Program Support Aircraft

General Characteristics

Twin-engine, high performance tactical aircraft

Length (ft):	46	*Range/Endurance:*	930 NM
Span (ft):	21	*Cruise Speed (Kts):*	Mach 1.08
Max Weight (lb):	12,800	*Altitude (ft):*	40,000+
Payload (lb):	4,500+		

Utilization

Current Role:	Program Support: Astronaut Space Flight Readiness Training Aircraft
Quantity:	20
Total Hours FY18:	3,008.4
Aircraft Age:	46~52
Suitability:	Well Suited to Role
Estimated Service Life:	15+ years
Future Role(s):	Same
Servicibility Expectation:	Good. Nearly All Maintenance Is In House.
Projected Utilization:	3,000

Replacement Aircraft Requirements

Replace When:	When Training Requirement Is Redefined
Replacement Justification:	TBD
Replacement Criteria:	TBD
Recommed Replacement:	Must Meet Astronaut Training Requirements

Aircraft Information Sheet # 22

Johnson Space Center
General Dynamics WB-57F High Altitude Research Aircraft

General Characteristics

50's vintage bomber converted to high altitude research platmform.

Length (ft):	69	*Range/Endurance:*	2,500 NM
Span (ft):	122	*Cruise Speed (Kts):*	410
Max Weight (lb):	63,000	*Altitude (ft):*	60,000+
Payload (lb):	6,000		

Utilization

Current Role:	High Altitude Earth Science Research
Quantity:	3
Total Hours FY18:	126.6
Aircraft Age:	54
Suitability:	Well Suited to Role. One of A Kind Capability.
Estimated Service Life:	Indefinite
Future Role(s):	Reimbursable Research
Servicibility Expectation:	Good
Projected Utilization:	150

Replacement Aircraft Requirements

Replace When:	N/A
Replacement Justification:	Supportability
Replacement Criteria:	50-65K Altitude, 5,000+ lb Scientific Payload
Recommed Replacement:	Possible Global Hawk or Similar UAV

Aircraft Information Sheet # 23

Kennedy Space Center
Bell UH-1H "Huey II" Program Support Aircraft

General Characteristics

US Army light-lift utility helicopters. Single turboshaft engine. Recently remanufactured Huey II's.

Length (ft):	44.5	*Range/Endurance:*	2+ hours
Span (ft):	48	*Cruise Speed (Kts):*	120 / 100
Max Weight (lb):	10,500 / 9,500	*Altitude (ft):*	10,000
Payload (lb):	4,000 / 3,000		

Utilization

Current Role:	Shuttle Contingency; Security; Wildfile Control; Surveillance
Quantity:	3
Total Hours FY18:	299.0
Aircraft Age:	40+
Suitability:	Adequate. Single Engine Limits Overwater Ops.
Estimated Service Life:	10 years
Future Role(s):	Same
Servicibility Expectation:	Increasingly Costly to Maintain
Projected Utilization:	300

Replacement Aircraft Requirements

Replace When:	N/A
Replacement Justification:	N/A
Replacement Criteria:	N/A
Recommed Replacement:	N/A

Aircraft Information Sheet # 24

Langley Research Center
Raytheon Be-200 Super King Air Program Support Aircraft

General Characteristics

Twin-engine pressurized turboprop aircraft. Seating modified to accommodate one pilot and four researchers.

Length (ft):	43.8	*Range/Endurance:*	1,250 NM / 6.2 hrs
Span (ft):	54.5	*Cruise Speed (Kts):*	260
Max Weight (lb):	13,500	*Altitude (ft):*	35,000
Payload (lb):	4,100		

Utilization

Current Role:	Earth Science Research
Quantity:	2
Total Hours FY18:	457.0
Aircraft Age:	36~39
Suitability:	Good
Estimated Service Life:	5-10 years
Future Role(s):	Earth Science Research; and Possibly Aeronautics & Constellation
Servicibility Expectation:	Good. Parts Available from Hawker Beechcraft.
Projected Utilization:	450

Replacement Aircraft Requirements

Replace When:	When Not Required
Replacement Justification:	Supportability
Replacement Criteria:	TBD
Recommed Replacement:	Meet Mission Requirements

Aircraft Information Sheet # 25

Langley Research Center
Cessna 206 Stationair Research Aircraft

General Characteristics

All-metal, six-place, single-engine aircraft used for flight research. Modified to seat one pilot and two researchers.

Length (ft):	28.3	*Range/Endurance:*	700 NM / 5.7 hrs
Span (ft):	36	*Cruise Speed (Kts):*	150
Max Weight (lb):	3,600	*Altitude (ft):*	15,700
Payload (lb):	1,175		

Utilization

Current Role:	Aviation Safety Programs; General Aviation Programs
Quantity:	1
Total Hours FY18:	43.0
Aircraft Age:	18
Suitability:	Excellent
Estimated Service Life:	30+ years
Future Role(s):	Same
Servicibility Expectation:	Excellent
Projected Utilization:	50

Replacement Aircraft Requirements

Replace When:	N/A
Replacement Justification:	N/A
Replacement Criteria:	N/A
Recommed Replacement:	N/A

Aircraft Information Sheet # 26

Langley Research Center
Lancair Columbia 300 Research Aircraft

General Characteristics

New generation light, single-engine, composite construction, 4-place, fixed gear aircraft.

Length (ft):	25.2	*Range/Endurance:*	1,000 NM / 7.2 hrs
Span (ft):	35.8	*Cruise Speed (Kts):*	180
Max Weight (lb):	3,400	*Altitude (ft):*	18,000
Payload (lb):	1,026		

Utilization

Current Role:	General Aviation Programs. Flyable Storage.
Quantity:	1
Total Hours FY18:	19.7
Aircraft Age:	17
Suitability:	Excellent
Estimated Service Life:	30+ years
Future Role(s):	Aeronautics Research.
Servicibility Expectation:	Excellent
Projected Utilization:	50

Replacement Aircraft Requirements

Replace When:	N/A
Replacement Justification:	N/A
Replacement Criteria:	N/A
Recommed Replacement:	N/A

Aircraft Information Sheet # 27

Langley Research Center
Cirrus HU-25 Research Aircraft

General Characteristics

Twin turbofan US Coast Guard aircraft modified for Airborne Science Research.

Length (ft):	56.3	*Range/Endurance:*	1900 NM
Span (ft):	53.5	*Cruise Speed (Kts):*	430
Max Weight (lb):	32,000	*Altitude (ft):*	42,000
Payload (lb):	3,000		

Utilization

Current Role:	Scientific Research
Quantity:	1
Total Hours FY18:	75.1
Aircraft Age:	36
Suitability:	Good
Estimated Service Life:	10+
Future Role(s):	Being Replaced by G-III
Servicibility Expectation:	Fair
Projected Utilization:	150

Replacement Aircraft Requirements

Replace When:	Being replaced with G-III.
Replacement Justification:	
Replacement Criteria:	
Recommed Replacement:	

Aircraft Information Sheet # 28

Langley Research Center
Cirrus SR-22 Research Aircraft

General Characteristics

New generation light, single-engine, composite construction, 4-place, fixed gear aircraft. Modified to carry one pilot and two researchers.

Length (ft):	26	*Range/Endurance:*	970 NM / 6.1 hrs
Span (ft):	38.3	*Cruise Speed (Kts):*	175
Max Weight (lb):	3,400	*Altitude (ft):*	17,500
Payload (lb):	932		

Utilization

Current Role:	General Aviation Programs
Quantity:	1
Total Hours FY18:	46.1
Aircraft Age:	17
Suitability:	Excellent
Estimated Service Life:	30+ years
Future Role(s):	Same
Servicibility Expectation:	Excellent
Projected Utilization:	50

Replacement Aircraft Requirements

Replace When:	N/A
Replacement Justification:	N/A
Replacement Criteria:	N/A
Recommed Replacement:	N/A

Aircraft Information Sheet # 29

Goddard Space Flight Center - Wallops Flight Facility
Raytheon Be-200 Super King Air Program Support Aircraft

General Characteristics

Twin-engine pressurized turboprop aircraft. Typical seating is for 6-8 passengers.

Length (ft):	43.8	*Range/Endurance:*	1,490
Span (ft):	54.5	*Cruise Speed (Kts):*	272
Max Weight (lb):	12,500	*Altitude (ft):*	30,000
Payload (lb):	1,850		

Utilization

Current Role:	Pilot Proficiency Training, Range Surveillance, & Pax Transport.
Quantity:	1
Total Hours FY18:	158.9
Aircraft Age:	38
Suitability:	Excellent. Good Balance for Mission. Economical.
Estimated Service Life:	10+ years
Future Role(s):	Same
Servicibility Expectation:	Excellent
Projected Utilization:	200

Replacement Aircraft Requirements

Replace When:	Not Recommended
Replacement Justification:	N/A
Replacement Criteria:	N/A
Recommed Replacement:	N/A

Aircraft Information Sheet # 30

Goddard Space Flight Center - Wallops Flight Facility
C-23 Sherpa Program Support Aircraft

General Characteristics

Twin-engine unpressurized turboprop aircraft. Max crew of 10.

Length (ft):	58.1	*Range/Endurance:*	1800 NM / 7 hrs
Span (ft):	74.8	*Cruise Speed (Kts):*	272
Max Weight (lb):	27,100	*Altitude (ft):*	20,000
Payload (lb):	7,000		

Utilization

Current Role:	Scientific Research and Cargo Carriage
Quantity:	1
Total Hours FY18:	0.0
Aircraft Age:	29
Suitability:	Excellent. Good Balance for Mission. Economical.
Estimated Service Life:	15+ years
Future Role(s):	Scientific Research and Cargo Carriage
Servicibility Expectation:	Excellent
Projected Utilization:	50

Replacement Aircraft Requirements

Replace When:	
Replacement Justification:	
Replacement Criteria:	
Recommed Replacement:	

Aircraft Information Sheet # 31

Goddard Space Flight Center - Wallops Flight Facility
Goddard Space Flight Center - C-130 Hercules Research Aircraft

General Characteristics

Four-engine turboprop aircraft extensively modified to support Airborne Science.

Length (ft):	97.8	*Range/Endurance:*	3000 NM / 12 hrs
Span (ft):	132.6	*Cruise Speed (Kts):*	290
Max Weight (lb):	155,000	*Altitude (ft):*	33,000
Payload (lb):	36,500		

Utilization

Current Role:	Scientific Research and Cargo Carriage
Quantity:	1
Total Hours FY18:	315.7
Aircraft Age:	30+
Suitability:	Excellent. Good Balance for Mission. Economical.
Estimated Service Life:	10+ years
Future Role(s):	Scientific Research and Cargo Carriage
Servicibility Expectation:	Excellent
Projected Utilization:	250

Replacement Aircraft Requirements

Replace When:	No future missions.
Replacement Justification:	
Replacement Criteria:	
Recommed Replacement:	

Aircraft Information Sheet # 32

Goddard Space Flight Center - Wallops Flight Facility
Lockheed Martin P-3B Research Aircraft

General Characteristics

Former US Navy long endurance, 4-engine maritime patrol aircraft. Converted to multi-function Earth Science research platform.

Length (ft):	116.5	*Range/Endurance:*	13+ hours
Span (ft):	99.5	*Cruise Speed (Kts):*	330
Max Weight (lb):	127,500	*Altitude (ft):*	28,300
Payload (lb):	15,000		

Utilization

Current Role:	Earth Science Research
Quantity:	1
Total Hours FY18:	440.2
Aircraft Age:	50
Suitability:	Excellent
Estimated Service Life:	10-20 years
Future Role(s):	Same
Servicibility Expectation:	Fair
Projected Utilization:	500

Replacement Aircraft Requirements

Replace When:	Not Required
Replacement Justification:	Supportability
Replacement Criteria:	Equal Payload & Range. Better Speed & Altitude.
Recommed Replacement:	Must Meet Research Requirements.

NASA Missions supported
in
Fiscal Year 2018

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Appendix 3 – FY18 Aircraft Missions

NASA Missions Supported in FY 2018

Location	Aircraft	Primary Utility Designation	Qty	Programs/Projects/Campaigns Supported
ARC	Sierra UAS ship B	R&D	1	Flight Qualification & UAS-NAS.
Subtotal ARC			**1**	
AFRC	B-200 (N7NA & N801NA)	PS	2	Ocean Current Measurement, ER-2 Deployment Support, & Pilot Proficiency.
	C-20A (Gulfstream G-III: N502NA)	R&D	1	UAVSAR CA and CO, ABoVE, & Hurricane Florence Response
	DC-8 (N817NA)	R&D	1	HIWC-II, OIB Antarctica, EVS/ATom 3 & 4 Campaigns, ND/MAX, & SARP 2018
	ER-2 (N806NA & N809NA)	R&D	2	Air-LUSI, CARE, HyspIRI HyTES HI, ACEPOL, SARP 2018, SHOW and CAMLS, & Pilot Proficiency.
	F-15B (N836NA)	R&D	1	Aeronautics Technology Research Testbed
	F-15D (N884NA & N897NA)	PS / R&D	2	High Performance Safety Chase.
	F/A-18 (N843NA, N846NA, & N850NA)	PS	3	Pilot Proficiency Training & High Performance Safety Chase. Sonic Boom Mitigation Flight Research.
	Global Hawk (N872NA)	R&D	2	UAV Tech Demo (Reimbursable)
	Gulfstream G-III (N808NA)	PS	1	Pilot Proficiency Training and Project Support
	Gulfstream G-III (N804NA)	R&D	1	ACTE Technology Development
	Ikhana (N870NA) (UAS)	R&D	1	UAS-NAS
	SOFIA (N747NA)	R&D	1	Infrared Astronomy and Airborne Astronomy Ambassadors Program.
	T-34C (N865NA)	PS	1	Pilot Proficiency Training & Low Speed Safety Chase.
	TG-14	PS	1	Sonic Boom Research Support
	X-56	R&D	1	Aeronautics Technology Research Testbed
Subtotal AFRC			**21**	
GRC	DHC-6 (N607NA)	R&D	1	GRAINEX, Great Lakes Algae
	S-3B (N601NA)	R&D	1	UAS-NAS & USAF Remibursable Work
	T-34C (N608NA & N609NA)	PS	2	UAS-NAS, Pilot Proficiency, and USAF Reimbursable Work.
Subtotal GRC			**4**	
GSFC	B-200 (N8NA)	PS	1	Pilot Proficiency, Range Security, & Pax. Transport.
	C-23 (N430NA)	R&D	1	CARVE
	C-130 (N439NA)	R&D	2	NAAMES, ACT-America, & OMG
	P-3 (N426NA)	R&D	1	OIB Antarctica, ORACLES, Pilot Proficiency
Subtotal GSFC			**5**	
JSC	B-377 Super Guppy (N941NA)	PS	1	Outsized Cargo Transport for HEOMD and DOD.
	Gulfstream G-III (N992NA)	PS	1	OMG, GLISTIN-A (Kilauea Eruption, ABoVE, Astronaut Direct Return, Pilot Proficiency.
	Gulfstream G-V (N95NA)	PS	1	Astronaut Direct Return, HIWC-II, & Pilot Proficiency.
	T-38	PS	20	Astronaut Space Flight Readiness Training (SFRT).
	WB57 (N926NA, N927NA, & N928NA)	R&D	3	SFRT, Navy TPS Flights, & CAT Phase B
Subtotal JSC			**26**	
KSC	UH-1H (N416NA, N418NA, & N419NA)	PS	3	Space Launch Security & KSC Center Support.
Subtotal KSC			**3**	
LaRC	B-200 (N528NA & N529NA)	PS	2	ACT America, HALO, LISTOS, XVS, IPDA, Azeem Rocket Launch, & Pilot Proficiency.
	Cessna C206 (N504NA)	R&D	1	EPA TEROS, ISAAC, & Pilot Proficiency
	Cirrus SR-22 (N501NA)	R&D	1	XVS, UAS-NAS, Osh Kosh Air Show, & Pilot Proficiency.
	Gulfstream G-III	R&D	1	Being prepared to replace the HU-25.
	HU-25 (N525NA)	R&D	1	LISTOS, ACT America, TASAR, MAAGIC, HAARTS, XVS, & Pilot Proficiency.
	Lancair (N507NA)	R&D	1	XVS & Pilot Proficiency
Subtotal LaRC			**7**	
Total NASA			**67**	

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Aircraft Mishaps
from
Fiscal Years 2004 to 2017

Appendix 4 – Fiscal Year 2004 to 2017 Aircraft Mishaps

Fiscal Year 2004 Aircraft Mishaps

Mishap Type	Mishap Descriptions
Type B	• T-38 bird strike during day Visual Flight Rules (VFR) flight
	• T-38 bird strike during night Visual Flight Rules (VFR) flight
Type C	• NASA 1 right windshield cracked during landing approach
	• Shuttle Trainer Aircraft (STA) lost thrust reverser in flight
	• T-38 struck approach lights during touch and go
	• DC-8 departed runway during take-off roll
	• DC-8 cabin lights damaged due to improper power handling while on ground *
Type D	• NASA 1 lost nose wheel steering due to shearing of steering wheel actuator while landing
	• DC-9 flap drooped and impacted maintenance stand in hangar overnight *
	• Shuttle Trainer Aircraft nose gear warning light illuminated during shuttle simulation approach
	• T-38 engine overheated during ground high-power run *
	• T-38 canopy found damaged on the floor in sheet-metal shop *
	• B-52 nitrogen hose damaged during maintenance *
	• Lift strikes DC-8 during maintenance *

Fiscal Year 2005 Aircraft Mishaps

Mishap Type	Mishap Description
Type C	• DFRC DC-8 engine inspection required as a result of improper ground transportation *
	• JSC T-38 engine Foreign Object Damage during ground run *
	• JSC G-II (STA) nose gear door closed on pilot *
Type D	• DFRC B-52B wing strike of ground vehicle during tow *
	• JSC G-II (MMA) bird strike on landing approach
	• JSC G-II (MMA) aircraft radome damage in flight
	• JSC T-38 aircraft struck by lightning on ground *
	• JSC T-38 bird strike compressor damage after take off
	• LaRC C-206 rolled over open tie-down pit during tow *

*** Ground mishaps**

Fiscal Year 2006 Aircraft Mishaps

Mishap Type	Mishap Description
Type C	• JSC T-38 maintenance stand hydraulic hose ruptured. *
	• JSC T-38 ground aborted due to engine Foreign Object Damage (FOD). *
	• JSC T-38 engine damage. *
	• JSC T-38 in-flight bird strike resulting in engine damage.
	• MSFC G-II flight aborted due to cross wind and questionable directional control causing damage.
Type D	• GRC DHC-6 right engine inlet heater overheated in flight, damaging engine cowling.
	• JSC T-38 in-flight bird strike to landing gear.
	• JSC T-38 engine damage due to Foreign Object Damage (FOD). *
	• JSC T-38 in flight lightning strike.
	• JSC T-38 maintenance personnel injured scalp after hitting aircraft radio antenna. *
	• JSC Super Guppy flight engineer slipped on cargo pallet during loading. *
	• JSC Shuttle Carrier Aircraft (SCA) had an engine fire on initial climb after takeoff.
	• WFF DC-8 in-flight lightning strike.

Fiscal Year 2007 Aircraft Mishaps

Mishap Type	Mishap Description
Type B	• JSC Gulfstream G-III heat damage to pylon.
Type C	• DFRC B-200 Engine FOD.
	• JSC T-38 bird strike.
	• JSC T-38 bird strike during rotation. Take off aborted.
	• JSC WB-57 brake fire. *
	• JSC STA ground towing incident. *
	• KSC Gulfstream G-II compressor stalled during take off.
Type D	• KSC Gulfstream G-II bird strike during landing.

*** Ground mishaps**

Fiscal Year 2008 Aircraft Mishaps

Mishap Category	Mishap Description
Type C	• N941 Super Guppy struck by tow tractor during towing. *
	• T-38 bird strike during take off.
	• N912 T-38 bird strike during during practice approaches.
	• P-3 struck model aircraft while being towed into hangar. *
	• N941 Super Guppy #2 engine damaged during installation. *
Type D	• N924 T-38 struck threshold lights during landing.
	• STA struck tree duing landing approach.
	• NASA 4 (G-II) compressor stalled on takeoff roll. *
	• N966 T-38 entered a storm and suffered hail damage.
	• Fuel tank and engine mount failure prevented Sierra UAS from takeoff. *
	• N908 T-38 engine damage due to bird ingestion on run up to Military Power. *
	• N911 SCA elevator struck by manlift during repair of vertical stabilizer. *
	• N955 T-38 cockpit canopy separated during ground mx. and damaged windscreen. *

Fiscal Year 2009 Aircraft Mishaps

Mishap Type	Mishap Category	Mishap Description
Type C	In Flight	All four engines rolled back as Super Guppy aircraft cleared the runway.
	Ground	B-747SP (SOFIA) vertical stab damaged during removal.
		Global Hawk UAS CAMA (Common Aircraft Modem Assembly) mishap in hangar.
		Huey II helicopter struck platform and ground mechanic fell and got injured.
Type D	In Flight	T-38 aircraft (N912NA) had an engine flame out due to FOD.
		Vulture impacted Huey II helicopter while in flight.
	Ground	During inspection on T-38 aircraft, it was noted that #1 engine had FOD damage.
		Gulfstream G-II aircraft (N949NA) damaged by B1 Stand.
		T-38 suffered a bird strike on T-38 ramp during maintenance ground run.
		T-38 aircraft (N918NA) was dented by blade of concrete cutter.
		Gulfstream G-II (N949NA) Nose Gear door damaged by steering pin retainer clip.
		B-747SP (SOFIA) Upper Rigid Door (URD) seal and seal retainer damaged.
		B-747SP (SOFIA) Emergency Slide Door 2 Left lower cell aspirator turbine disintegrated and exited its housing, throwing turbine blades into observers.

*** Ground mishaps**

Fiscal Year 2010 Aircraft Mishaps

Mishap Type	Mishap Category	Brief Description
Type B	Ground	F-18 engine FOD.
Type C		ER-2 towing incident.
Type D	In Flight	Bird ingested into T-38 engine.
		T-38 landing light lost during flight.
		T-38 bird strike.
		In flight damage to Shuttle Carrier Aircraft (SCA) engine panel.
	Ground	T-38 engine FOD.
		WB-57 pitot tube dropped and bent.
		T-38 lap belt initiator lanyard snag.
		T-38 engine blade damage discovered during flight inspection on ground.
		T-38 electrical problem on the ground,
		Manlift impacted Shuttle Carrier Aircraft (SCA) engine cowling.
		Shuttle Trainer Aircraft (STA) aircraft wing damaged during tire change.
		T-38 right wing assembly damaged on the ground.
		T-38 battery shunt damaged while being prepared for towing.
		Dual output seat initiator fired during T-38 seat removal.

Fiscal Year 2011 Aircraft Mishaps

Mishap Type	Mishap Category	Brief Description
Type C	Flight	T-38 engine flame out on takeoff.
		T-38 bird strike on touch & go takeoff.
		T-38 bird strike on takeoff.
Type D	Flight	T-38 engine foreign object damage (FOD).
		T-38 tire blew during landing.
		T-38 canopy jettison actuation.
		T-38 bird strike during landing.
	Ground	SOFIA bleed air leak.
		B-377 Supper Guppy throttle cable failure.
		T-38 cockpit display crack discovered.

Fiscal Year 2012 Aircraft Mishaps

Mishap Type	Mishap Category	Brief Description
Type C	Flight	T-38 bird strike on touch & go climb out.
	Ground	ER-2 main gear door damaged during phase maintenance.
		F-18 cockpit “heads-up” display damaged during shipment to depot.
Type D	Flight	DC-8 #1 engine flameout at FL250.
		Super Guppy grazed pole-mounted security camera during taxi.
		T-38 suffered a lightning strike.
		T-38 lighting strike.
	Ground	ER-2 tail wheel door damaged by towbar #1.
		ER-2 tail wheel door damaged by towbar #2.
		SOFIA unannounced power cut off during INF pump down.
		ER-2 damage to canopy thruster pin.
		SOFIA transformer overheated during power test of new wire installation.
		DC-8 air-stair impacted a Cessna 172.
		C-9 severe corrosion due to water intrusion to Air Data Display Unit.
		B747 aircraft tow bar broke.
		T-38 T-5 motor harness torn in half during engine removal.
		Data plates to two UH-1H main rotor head drag braces were destroyed.

Fiscal Year 2013 Aircraft Mishaps

Mishap Type	Mishap Category	Brief Description
Type C	Flight	T-38 bird strike on takeoff.
		Loss of engine thrust resulted in the SIERRA UAS gliding into the ocean.
Type D	Flight	WB-57 engine structural component/panel lost in flight.
		PODEX GISS RSP science sensor damaged in flight on ER-2.
	Ground	Global Hawk (N872NA) right-hand wing damage during ground handling.
		SOFIA aircraft systems failure of Telescope Assembly (TA) Power Unit "B," which provided power to the TA bearing float system pump.
		DC-8 experimenter probe damaged.
		Rudder rig pin not removed during C-20A aircraft service change and subsequent flight control checks, causing damage to hat channel and web.
		C-9 heat exchanger dropped ruing scheduled maintenance.
		C-9 aft evacuation slide inflation.

Fiscal Year 2014 Aircraft Mishaps

Mishap Type	Mishap Category	Brief Description
Type C	Ground	Employee got index finger on right hand caught in spring on aircraft hatch door as he was stepping down.
Type D	Flight	Power Supply Failed in Flight.
		Power Supply Failed in Flight.
		Missing Tool located in Telescope Assembly (TA) Cavity

Fiscal Year 2015 Aircraft Mishaps

Mishap Type	Mishap Category	Brief Description
Type C	Flight	Contractor X-56 Buckeye UAS entered pogo mode during landing and crashed.
	Ground	Global Hawk UAS impacted guard-rail during tow.
Type D	Flight	GL-10 multi-rotor, tilt-wing UAS crashed into trees surrounding UAS runway.

Fiscal Year 2016 Aircraft Mishaps

Mishap Type	Mishap Category	Brief Description
Type C	Ground	Employee injured rotator cuff and tendons in right shoulder due to pulling nose gear to turn the wheel on an aircraft.
Type D	Ground	On preflight, found ER-2 M-11 thruster body had come loose.

Fiscal Year 2017 Aviation Mishaps

Mishap Type	Mishap Category	Brief Description
Type C	Ground	Post-flight inspection found FOD damage to engine compressor at intake of C-130.
Type D	Flight	Bird strike damage to an F-18 engine.
	Ground	Pitot-static damaged during test; no injuries.

NASA Aircraft Requirements
And
Link to Strategic Plan

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FY 2018 Annual NASA Aircraft Report
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Appendix 5 – Aircraft Linkage to NASA's Strategic Plan

Location	Acive Aircraft	MD/Prog Requirements	Strategic Goals Supported
ARC	SIERRA UAS	ARMD/SMD research data collection	3
AFRC	B-747, (N747NA (SOFIA))	SMD Stratospheric Observatory for IR Astronomy	1, 3, 4
	DC-8-72 (N817NA)	SMD heavy Research/data collection (1K - 40K'), long range	1, 3
	Global Hawk UAS	SMD unmanned high altitude, ultra long duration research/data collection	3, 4
	G-III (N502NA (C-20))	SMD research/data collection UAVSAR	1, 3
	G-III (N804NA)	ARMD reseach/data collection	3, 4
	G-III (N808NA)	ARMD/ATP Pilot Proficiency Training	1, 3, 4
	ER-2 (N806NA, N809NA)	SMD high altitude research/data collection (70K or greater), long duration	1, 3
	B200 (N7NA, N801NA)	Pilot Proficiency Training	1, 3, 4
	T-34C (N865NA)	ARMD/ATP Pilot proficiency training, slow UAS chase	1, 3, 4
	F-15B (N836NA)	ARMD/FA high speed/performance research	3, 4
	F-15D (N884NA, N892NA)	ARMD/ATP high speed/performance research	1, 4
	F/A-18A/B (N850NA, N867NA, N868NA)	ARMD/ATP high speed chase/support and proficiency training	1, 4
	TG-14 (N856NA)	Motor Glider	3, 4
	X-56 MUTT	Multi-Utility Technology Testbed	3
	X-57 Maxwell	All electric x-plane	3
	X-59 LBFD	Low Boom Flight Demonstrator	3, 4
GRC	DHC-6 (N607NA)	ARMD AvSafety/SMD and research reimbursable	1, 3, 4
	S-3B (N601NA)	SMD and research reimbursable	3
	T-34C (N603NA, N608NA)	Pilot proficiency training	1, 3
GSFC	B-200 (N8NA)	Pilot proficiency training, range support	1, 3, 4
	C-130 (N439NA)	SMD and research cargo transport	1, 3
	P-3 (N426NA)	SMD research/data collection	1, 3
JSC	B-377 (N941NA (Super Guppy))	HEO Large space vehicle component transport	2, 3, 4
	G-III (N992NA)	ISS Astro Transport/SMD UAVSAR	1, 2, 3, 4
	G-V (N95NA)	Support-Astro return	1, 2, 3, 4
	T-38	HEO Astronaut Flight Training and Proficiency	1, 2, 3, 4
	WB-57 (N926NA, N927NA, N928NA)	SMD High altitude, large payload science	1, 2, 3, 4
KSC	UH-1H (N417NA, N418NA, N419NA)	Launch and range security . Bio & Environmental compliance	1, 2, 3, 4
LaRC	B-200 (N529NA (UC-12), N529NA)	SMD research/data collection	1, 4
	Cessna C-206 (N504NA)	* To be loaned to WFF	
	Cirrus SR-22	ARMD research and pilot proficiency	1, 3, 4
	Falcon HU-25 (N525NA) / Being replaced by G-III.	SMD research	1, 3
	G-III (N520NA (C-20))	SMD research	1, 2
	LC40 Cessna	ARMD-V&V cockpit display technology	1, 3, 4

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