SpacePolicyOnline.com
A product of Space and Technology Policy Group, LLC

Fact Sheet
May 17, 2018

NASA'S FY2019 BUDGET REQUEST

Introduction

President Trump is **requesting $19.892 billion** for NASA in FY2019. The request was made before Congress finalized action on FY2018 appropriations. Eventually, Congress appropriated $20.736 billion so the request is $844 million less than NASA's current funding level.

That $19.892 billion request includes an extra $300 million added just prior to release of the budget request on February 12, 2018 based on an agreement reached by Congress on February 9, 2018 that raised budget caps imposed by the 2011 Budget Control Act. The $300 increase is only for FY2019. Projected funding for NASA in FY2020 drops back to $19.6 billion and remains level through FY2023 (the "out-years"), with no increase for inflation.

- The House Science, Space, and Technology (SS&T) Committee approved a FY2018-2019 NASA authorization bill, H.R. 5503, on April 17, 2018. It authorizes $21.21 billion for NASA for FY2019, an increase of $1.3 billion over the President's request.

- **The House Appropriations Committee approved $21.546 billion** on May 17, 2018, an increase of $1.654 billion above the request and $810 million above FY2018.

Table 1 below shows the President's FY2019 request compared to NASA's FY2017 and FY2018 appropriations levels and the House committees' actions. Table 2 shows the out-year projections included in NASA's FY2019 request, which are notional. NASA has reformulated its budget accounts for FY2019 and beyond making comparisons with prior years difficult. The two tables in this report follow the new NASA format, although Congress will ultimately decide on NASA's budget account structure.

Key Issue: The New Moon Program versus Other NASA Priorities

The marquee issue for NASA this year is the Trump Administration's plan to return humans to the Moon with no commensurate increase in NASA's budget. In fact, the budget projections do not even include an adjustment for inflation, so the agency's purchasing power will decline over the 5-year runout. Instead, the Administration wants to redirect NASA funding from existing programs to pay for the Moon mission. Two programs targeted this year are the International Space Station (ISS) and a new space telescope (WFIRST).

By Marcia S. Smith ©Space and Technology Policy Group, LLC. All Rights Reserved

NASA, the Moon, and Mars

As then-Acting NASA Administrator Robert Lightfoot said in a "State of NASA" address to employees on February 12, 2018, the Trump Administration is putting NASA "on a path to return to the Moon with an eye towards Mars."

The carefully worded statement avoids any commitment to when either of those objectives might be accomplished. The Obama Administration was committed to placing astronauts in orbit around Mars in the 2030s, bypassing trips to the lunar surface, but performing missions in lunar orbit ("cis-lunar" space) to test out systems and build a small "gateway" space station as a transit point for astronauts traveling between Earth and Mars.

The Trump FY2019 budget request keeps the lunar orbit gateway (Lunar Orbital Platform-Gateway), but restores the goal of returning astronauts to the lunar surface before going to Mars. The timeline for the gateway is roughly similar to the Obama plan (early 2020s), but there is no official date for when astronauts would land on the Moon or reach Mars. Lightfoot said in February 2018 that he anticipates astronauts will return to the lunar surface late in the 2020s.

Trump is the third president since the end of the Apollo program in 1972 to direct NASA to return astronauts to the Moon and then go on to Mars. George H.W. Bush and George W. Bush were the others. Obama chose to skip the Moon and focus only on Mars. Yet 45 years later, the Apollo 17 crew remains the last to travel beyond low Earth orbit, never mind set foot on another planetary body.

A Brief History

On May 25, 1961 in a speech to Congress on Urgent National Needs, President John F. Kennedy called on the country to adopt the goal of landing a man on the Moon by the end of the decade and returning him safely to Earth. Thus began the Apollo program, which was strongly supported by President Lyndon Johnson after Kennedy's assassination in 1963. The first mission to orbit the Moon, Apollo 8, took place in the final weeks of Johnson's presidency.

All of the six successful Apollo lunar landings (Apollo 11, 12, 14, 15, 16, and 17) occurred during the presidency of Richard Nixon, but he did not support the effort and cancelled three additional lunar landing missions that were planned. Soon after taking office he directed his Vice President, Spiro Agnew, to lead a Space Task Group to recommend a post-Apollo program. The report called for building a reusable space transportation system to take astronauts to a space station in low Earth orbit and embark on human trips to Mars as early as the 1980s.

Nixon approved only the space transportation system – the space shuttle. The shuttle program – and only the shuttle program – continued to have support from Presidents Ford and Carter and in the early years of the Reagan Administration.

In 1984, however, NASA Administrator Jim Beggs convinced Reagan to move forward with the next step in the program, an Earth orbiting space station (discussed below).

Five years later, just six months after taking office and on the 20th anniversary of the Apollo 11 Moon landing, President George H.W. Bush announced the Space Exploration Initiative (SEI) to

© Space and Technology Policy Group, LLC. All Rights Reserved.

return astronauts to the Moon and then go on to Mars. Congress was unwilling to provide the requisite funds, however. These were the Gramm-Rudman-Hollings years of deficit reduction, and while NASA did comparatively well as it recovered from the 1986 space shuttle Challenger tragedy, there was no appetite for a bold human spaceflight program beyond the space shuttle and space station programs. SEI withered.

President Clinton, and President George W. Bush during his first three years in office, continued to support the shuttle and space station programs, but nothing beyond that.

In 2004, however, almost exactly one year after the space shuttle Columbia tragedy, President Bush announced a new Vision for Space Exploration (VSE) similar to his father's SEI. He directed NASA to return astronauts to the lunar surface by 2020 and then go on to Mars. The VSE responded to a finding from the Columbia Accident Investigation Board (CAIB) that no compelling national mandate existed for sending humans into space and a national vision was needed.[1] VSE was intended to be that vision.

As with his father's SEI, the question remained as to how to fund the program. Bush promised to add $1 billion to NASA's budget over 5 years, but also announced that once the space shuttle was flying again, it would be used only until construction of the space station was completed in 2010. The Bush Administration also signaled that it planned to end U.S. support for the space station in 2015. That would make the billions per year spent on shuttle and ISS available for the Moon/Mars program. Money also was taken from NASA's science programs during that era, but it was to pay for the space shuttle program, not for Moon/Mars.

NASA initiated the Constellation program to execute Bush's Moon/Mars directive, beginning development of a big new rocket, Ares V, and a crew spacecraft, Orion. (A smaller Ares I would be developed to take astronauts to ISS.) Those efforts were underway in 2009 when Barack Obama became President. He established a Blue Ribbon panel, the Augustine Committee, to review Constellation and present options (not recommendations) on the future path of the U.S. human spaceflight program. The Augustine Committee concluded NASA needed an additional $3 billion per year for Constellation to succeed.

The Obama Administration determined Constellation was not affordable. It restructured the program to bypass a human return to the lunar surface, thus avoiding the costs of developing systems to land and operate there. Instead, the focus would be on sending humans to orbit Mars in the 2030s, with a mission to an asteroid as a steppingstone.[2] (See prior year versions of this fact sheet for more on the Obama plan.)

The Obama Administration wanted NASA to cancel Ares and Orion, but Republicans and Democrats in Congress vehemently disagreed. A compromise was reached in the 2010 NASA Authorization Act, whereby NASA was directed to build a different big new rocket, the Space Launch System (SLS), and a Multi-Purpose Crew Vehicle (MPCV). NASA chose to continue

[1] The CAIB report contains many significant findings not only about the Columbia tragedy, but the overall human spaceflight program. It is well worth reading. In this context, Chapter 9 (section 9.3) is particularly relevant.
[2] The Asteroid Redirect Mission (ARM) never won widespread support in the space community or in Congress and was terminated by the Trump Administration as soon as it took office. Some of the technology developed for ARM will be used for the new Moon program.

© Space and Technology Policy Group, LLC. All Rights Reserved.

Orion as the MPCV. Development of SLS, Orion and associated Exploration Ground Systems continued throughout the Obama Administration at a cost of about $4 billion per year.

Today: The Trump Moon/Mars Initiative

Thus, the two basic elements needed to send humans beyond low Earth orbit (LEO)[3] – a big rocket and a crew spacecraft – were under development throughout the Obama Administration. The launch dates slipped, however. The first launch of SLS, without a crew, is now expected in 2020 instead of its most recent schedule of November 2018. The first launch with a crew will not be until 2023. The schedule remains fluid, however.

The Trump Administration wants to restore the goal of landing astronauts back on the Moon that the Obama Administration eschewed. The United States is the only country that has landed men on the Moon so far (the six Apollo crews from 1969-1972).

The question remains – where will the money come from? Like the George W. Bush Administration, it plans to get some of the money from cancelling existing programs. In the FY2019 request, U.S. direct support for ISS would end in 2025 and the next large space telescope, WFIRST, would be cancelled. The Trump Administration also hopes international and commercial partners will take on some of the responsibilities, an option earlier Administrations did not have.

Proposed Terminations to Support the Moon Program

Ending Direct NASA Support for ISS in 2025. The ISS has a long history. President Ronald Reagan directed NASA to build a permanently occupied space station in his 1984 State of the Union address. Europe, Canada and Japan quickly joined as partners in the Space Station Freedom program. After 9 years of cost growth and schedule delays, NASA was directed by President Bill Clinton to restructure the program in 1993. At the same time, with the end of the Cold War and the collapse of the Soviet Union, Russia joined as a partner. The revised program became known simply as the International Space Station (ISS).

Actual construction of ISS began with the launch of the first module, Zarya, in 1998 and was completed in 2010.[4] It has been permanently occupied by international crews rotating on 4-6 month shifts since November 2000. Under current law (the 2017 NASA Authorization Act), NASA is required to operate ISS at least until 2024 and study whether operations can continue until at least 2028, the 30th anniversary of the launch of the first module, or 2030.

The U.S. investment in ISS through the end of the construction phase in 2010 is variously listed as $60-100 billion, depending in part on how costs for the 40 space shuttle launches needed to

[3] LEO is generally considered to be an altitude of 2,000 kilometers (km) or less above the Earth. The International Space Station is in LEO. The human spaceflight community refers to human spaceflight as in LEO or "beyond LEO," a very broad range of potential destinations that includes the Moon and Mars.

[4] Zarya was built by Russia, but paid for by NASA and counts as a U.S. element of ISS. Construction of the U.S. segment of ISS was completed in 2010, although Russia still plans to launch a science module (it has been repeatedly delayed) and NASA allowed Bigelow Aerospace to attach a prototype expandable module, BEAM, in 2016. Other companies may attach hardware in the future.

© Space and Technology Policy Group, LLC. All Rights Reserved.

assemble it are calculated (average costs or marginal costs). NASA currently spends approximately $3.5-4 billion per year on ISS.[5]

As explained above, the George W. Bush Administration planned to end U.S. support of ISS in 2015, but the Obama Administration extended that first to 2020 and then to 2024.[6] NASA convinced the other partners to continue their support through then. Russia appears to be strongly committed to ISS. The U.S.-Russian relationship vis a vis ISS has not been affected by the changed geopolitical climate following Russia's annexation of the Crimea in 2014 or its apparent interference in U.S. elections. Europe, Canada and Japan appear less enthusiastic about continuing ISS, but NASA has been able to convince them to remain as partners so far.

ISS supporters, including key members of Congress like Sen. Ted Cruz (R-TX) and Bill Nelson (D-FL), want to continue ISS operations at least until 2028. Both were closely involved in drafting the 2017 NASA Transition Authorization Act, which requires NASA to submit a "transition plan" explaining how it will ensure a seamless transition from ISS to whatever will come next and estimating the cost to continue operating ISS through 2024, 2028 and 2030. The plan was due to Congress on December 1, 2017, but NASA did not meet that deadline.

Its core recommendation became known publicly just before the FY2019 budget request was released in February 2018: the Trump Administration wants to end direct government support for ISS in 2025 in the hope that the private sector will build and launch commercial LEO facilities by then and NASA can lease those facilities or purchase services thereafter. In the meantime, the government will provide funding to facilitate private sector efforts. The FY2019 budget request includes $150 million for that purpose, part of a total of $900 million over 5 years.

Bigelow Aerospace already has a prototype expandable module, BEAM, attached to the ISS and wants to launch full sized modules. Other companies have their own ideas with different designs including Nanoracks, Axion Space, and Orion Span.

China is planning to have a space station in LEO in the early 2020s. The prospect of China being the only country with a human space outpost in LEO is also of concern for reasons of national security and national prestige.

The complete 54-page ISS Transition report was delivered to Congress on March 30, 2018. In addition to explaining the new policy, the report contains a great deal of other information including the fact that all the major U.S. structural elements have been "cleared" to operate through December 2028. Ten other elements, including truss segments for the solar arrays and EXPRESS racks, are still undergoing review. The bottom line is that "analysis to date indicates that there would be sufficient remaining margin to operate even beyond 2028."

The report cautions, however, that how long ISS operates is not just a technical question, but financial. It includes a table showing those annual costs as exceeding $3 billion per year.

[5] The other ISS partners paid for their own modules and hardware and reimburse their share of operating costs through barter arrangements. Except for Russia, there is no exchange of money between the partners.
[6] Obama also added two more shuttle flights for logistics. Hence, the last shuttle flight was in 2011, not 2010.

© Space and Technology Policy Group, LLC. All Rights Reserved.

WFIRST. The Trump budget request would cancel NASA's next large space telescope, the Wide-Field Infrared Survey Telescope (WFIRST). It is the follow-on to the James Webb Space Telescope (JWST) scheduled for launch in 2020, which itself is a follow-on to the Hubble Space Telescope. WFIRST's purpose is to advance research into dark energy and dark matter and discover new planets orbiting other stars (exoplanets).

NASA's priorities for astronomy and astrophysics, as well as other space and Earth science disciplines, are set by Decadal Surveys performed every 10 years (a decade) by expert committees established by the National Academies of Sciences, Engineering, and Medicine. WFIRST was identified as the top priority for a large "flagship" space telescope by the most recent Decadal. Although WFIRST has encountered challenges largely due to design changes dictated by NASA in excess of what the Academies recommended, support for the telescope in the scientific community remains strong.

Historically, Decadal Surveys have been described as "bibles" for NASA's science programs because they represent a consensus of the science community on the most important scientific questions and what space missions are needed to answer them. Congress values the reports for the same reason.

Typically, NASA tells the expert committees when they begin their deliberations how much money it expects to have available over the next decade and the committees work from there as to what missions to propose. While there is no guarantee that their recommendations will be followed because budget projections are fraught with uncertainty, generally speaking NASA and Congress follow those priorities.

A number of changes were made by NASA to the WFIRST design and it requested feedback from the Academies on those changes. Two Academies reports, in 2014 and 2016, raised concerns about the cost and schedule impacts of those changes and an independent review released last year led NASA science head Thomas Zurbuchen to require a downscoping. But cancellation was not anticipated.

WFIRST's future has been complicated by continuing problems with JWST, however. JWST suffered substantial cost overruns and schedule delays, which led to a restructuring and rebaselining in 2011. At that time, NASA said JWST would cost $8 billion for development (not operations), with launch in 2018. Congress has capped the cost at that level every year since. In September 2017, however, NASA announced the launch would be delayed until 2019, and in March 2018 revealed another slip until at least May 2020. NASA is assessing the cost impact and will report to Congress in June.

What Is NASA's "Core Mission"?

The proposed cancellation of WFIRST is troubling to the science community not only because of the potential loss of that telescope, but more broadly for fear that science overall will suffer as resources are shifted to human exploration.

As shown in Table 2 below, the projected budgets for NASA's Earth science, astrophysics and heliophysics programs are flat through the out-years and for planetary science is declining. Since none include adjustments for inflation, the purchasing power of those dollars will be less.

© Space and Technology Policy Group, LLC. All Rights Reserved.

The reduction for astrophysics is compounded by the fact that the FY2019 request merges funding for the James Webb Space Telescope, which has had its own budget line for many years, into the rest of astrophysics and the combined total is cut by $165 million per year, or $825 million over the 5-year runout.

NASA officials have asserted that the decision to propose terminating WFIRST was not based on merit, but because it would cost $3.4-3.8 billion dollars (sometimes they say $3.2 - $3.9 billion) and that money is needed for the Moon program.

That decision is likely to reinvigorate the rivalry between science and human spaceflight that dates back to NASA's beginnings.

Science advocates point out that NASA's organic act, the 1958 National Aeronautics and Space Act, lists "expansion of human knowledge of the Earth and of phenomena in the atmosphere and space" as the first objective for the agency. The Act has been amended many times over the decades and new objectives have been added, but that remains first on the list. Development of systems to carry "living organisms" through space is third. (NASA's objectives as codified in law are listed in Appendix A.)

During the George W. Bush Administration, some Constellation advocates argued that human exploration is NASA's core mission and other programs had lower priority. Congress rejected that philosophy and passed legislation (the 2005 and 2008 NASA authorization acts) specifically stating that NASA should have a "balanced" set of science, aeronautics and human exploration missions. During the Obama Administration, NASA Administrator Charlie Bolden, a former astronaut, worked diligently to bridge the divide between science and exploration, with some success. The 2010 NASA Authorization Act restated language from the 2008 Act that NASA "is and should remain a multi-mission agency with a balanced and robust set of core missions in science, aeronautics and human space flight and exploration."

The most recent enacted authorization, the 2017 NASA Transition Authorization Act, was signed into law by President Trump in March 2017. It is even more specific, saying "NASA should be a multi-mission space agency, and should have a balanced and robust set of core missions in space science, space technology, aeronautics, human space flight and exploration, and education."

Nevertheless, on December 11, 2017, President Trump signed Space Policy Directive 1, which states that he is taking steps "to refocus NASA on its core mission of space exploration…," reinvigorating the debate over NASA's purpose and fears in the science community that more programs will be cancelled to pay for human spaceflight, with the proposed cancellation of WFIRST as the first salvo.[7]

[7] Then-Acting NASA Chief Financial Officer Andrew Hunter also characterized proposed cuts to NASA Earth science programs and its education office as part of the effort to redirect resources to human exploration. However, NASA proposed cancelling them last year, before the Moon program was announced. The cuts are being re-proposed this year because Congress has not yet completed action on the FY2018 budget request.

© Space and Technology Policy Group, LLC. All Rights Reserved.

Potential International and Commercial Partners

One major change from the Bush era is that international and commercial partners are expressing interest in participating in human exploration beyond LEO. No agreements have been made, but it offers some hope that this effort will turn out differently than those that preceded it.

International. NASA is discussing with its current space station partners (Russia, Europe, Canada and Japan) and others what they might be willing to contribute.

An International Space Exploration Coordination Group (ISECG) including the ISS partners and others has been meeting for many years. ISECG periodically issues Global Exploration Roadmaps that lay out shared goals.The most recent was issued in January 2018.

The U.S. State Department sponsored the first ministerial-level International Space Exploration Forum (ISEF) with world leaders from many countries in 2014. A second ISEF, ISEF-2, was held in Japan on March 3, 2018. NASA officials reported afterwards that there is considerable interest on the part of other countries to participate in the Moon program, but they need to be assured of a "constancy of purpose" on the part the United States. Scott Pace, Executive Director of the White House National Space Council, said the international partners were asking not whether they should participate, but how.

Commercial. The emergence of entrepreneurial U.S. commercial space companies is viewed as a hopeful sign that the U.S. government might not have to bear all the costs of the Moon/Mars program. How much of their own capital companies are willing to invest, and what prices they would charge NASA to use their facilities and services, is unknown at this point, so how much cost to the government might be avoided cannot be calculated at this time.

Companies like Elon Musk's SpaceX and Jeff Bezos's Blue Origin are building their own big rockets – Big Falcon Rocket (BFR) and New Glenn, respectively. Like SLS, they are still in development and when they might be ready is unclear. Musk and Bezos have their own plans for human exploration of space. Musk wants to send a million people to live on Mars in case Earth is destroyed by a catastrophe. Bezos wants a million people living and working in space.

Views differ on whether BFR and New Glenn negate the need for SLS or complement it. That debate has been ongoing for years. SLS advocates argue the government must build whatever it needs because commercial companies can change or even abandon their plans based on market considerations. They also insist that the government has a responsibility to maintain a world-class industrial base to respond to potential future threats. Commercial space advocates argue that the private sector can provide space transportation services for much less cost and the main reason the government is building SLS is politics – a jobs program to funnel money to certain states and congressional districts.

Other companies like Moon Express and Astrobotic are building small lunar landers. They already partner with NASA through the Lunar CATALYST technology program. Blue Origin wants to partner with NASA on a "lunar delivery service" it calls Blue Moon. The FY2019 request proposes a new Lunar Exploration and Discovery line item in the Planetary Science Division to provide $218 million per year to support commercial efforts ($200 million) plus operations of NASA's existing Lunar Reconnaissance Orbiter ($18 million).

© Space and Technology Policy Group, LLC. All Rights Reserved.

Second SLS Mobile Launch Platform

An issue that could affect the pace at which the Moon program proceeds is whether NASA should procure a second Mobile Launch Platform (MLP) for SLS. As discussed in our report on NASA's FY2018 budget, Congress added $350 million for a second MLP in the final version of the FY2018 appropriations bill.

NASA did not request funding for it either in FY2018 or FY2019. In fact, then-Acting NASA Administrator Robert Lightfoot told the House Science, Space, and Technology Committee on March 8, 2018 – before the appropriations bill was finalized on March 23-- that NASA had looked at the options and decided not to request funding to buy one.

There is only one MLP now and it is specifically designed to support the first SLS launch, which will use an Interim Cryogenic Propulsion Stage (ICPS) as the upper stage. That mission will launch the Orion spacecraft without a crew – Exploration Mission-1 (EM-1).

Until quite recently, all SLS launches after that were to use the Exploration Upper Stage (EUS), which is much larger in size and capability. The MLP must be modified to accommodate it, which will take 33 months, an almost three year hiatus during which no SLS launches could take place. If EM-1 is in 2020, that means EM-2, the first SLS/Orion flight with a crew, could not take place until 2023. Advocates want a second MLP built to meet the EUS requirements to shorten the interval between EM-1 and EM-2.

Despite Lightfoot's March 8 testimony, NASA has embraced the March 23 appropriations action and is now replanning SLS launches. Lightfoot told the House Appropriations Commerce-Justice-Science (CJS) subcommittee on April 12, 2018 that with a second MLP, NASA will have "flexibility" as to what the second SLS launch will carry. For example, NASA could purchase a second ICPS and use that combination to launch EM-2, although it would be less powerful and therefore would change the character of the EM-2 mission (e.g., the crew could not travel as far from Earth). Or an SLS/ICPS combination could be used to launch the Europa Clipper robotic mission (discussed below) earlier than NASA currently plans. The bottom line is that plans remain quite fluid.

Conclusion

In many respects, the debate over the Trump Moon/Mars proposal harkens back to the Bush Administration's VSE and Constellation. Questions about how to pay for the program and whether human exploration is NASA's core mission and has priority over science have reemerged. Scott Pace, Executive Secretary of the White House National Space Council, was NASA's Associate Administrator for Program Analysis and Evaluation at that time,[8] so some see the Trump proposal as a return to that plan.

[8] Michael Griffin was NASA Administrator then. He also has joined the Trump Administration, but at DOD, not NASA. He is the Under Secretary of Defense for Research & Engineering (USD/R&E).

© Space and Technology Policy Group, LLC. All Rights Reserved.

As noted, one difference this time is the potential that commercial and international partners might shoulder some of the burden. Another is Congress's willingness – even enthusiasm -- to fund NASA at a much higher level than requested by the Trump Administration.

OTHER FY2019 BUDGET ISSUES

Science

As already discussed, the rivalry between science and human exploration is likely to be resurrected as proposals are made to shift money in the science budget to support the Trump Moon program. Astrophysicists are alarmed not only by the proposed cancellation of WFIRST, but the projected cuts to astrophysics generally for the next 5 years. Earth science, planetary science, and heliophysics also will be tightly constrained.

Apart from astrophysics, the two science areas likely to receive considerable attention in this year's budget debate are held over from FY2018: Earth science and a robotic mission to Jupiter's moon Europa.

Earth Science

The Trump Administration is once again proposing termination of four NASA Earth science missions – PACE, CLARREO-Pathfinder, OCO-3, and DSCOVR's Earth-facing instruments. Congress rejected the Administration's proposal to cancel them in FY2018. NASA had also proposed cancelling a fifth – the Radiation Budget Instrument (RBI). It did not wait for congressional action in that case, however, terminating the program in January 2018. Congress did not disagree.

More information on the four programs targeted for elimination is in the fact sheet on the FY2018 budget request. Briefly they are:

- **PACE,** the Plankton, Aerosol, Clouds and Ocean Ecosystem spacecraft, which will provide high quality global observations about ocean health and its relationship to airborne particles and clouds. Among other things, the data would be used for fisheries management and responding to harmful algae blooms. Launch is currently planned for 2022-2023. PACE is being built and tested at NASA's Goddard Space Flight Center in Greenbelt, MD.

- **CLARREO Pathfinder and OCO-3** are instruments that would be attached to ISS. CLARREO is the Climate Absolute Radiance and Refractivity Observatory. In 2016, a decision was made to focus on a technology demonstration mission first – CLARREO Pathfinder, a Reflected Solar Spectrometer that would be attached to the ISS around 2020. CLARREO Pathfinder is managed by NASA's Langley Research Center in Hampton, VA.

  OCO is the Orbiting Carbon Observatory. The first OCO was lost in a launch failure. A replacement, OCO-2, was launched in 2014. OCO-3 would use spare parts from OCO-2 to build an instrument to be attached to the ISS and study the distribution of carbon

© Space and Technology Policy Group, LLC. All Rights Reserved.

dioxide on Earth as it relates to urban populations and changing patterns of fossil fuel combustion. OCO-3 is a project of the Jet Propulsion Laboratory (JPL) in Pasadena, CA.

- **DSCOVR, the Deep Space Climate Observatory,** was launched in 2015. Its primary mission is to provide space weather data and is funded by NOAA, not NASA. However, NASA designed and built two of the four instruments on DSCOVR: the Earth-Polychromatic Imaging Camera (EPIC) that constantly provides full-disk views of Earth from the spacecraft's vantage point 1.5 million kilometers away, and the National Institute of Standards and Technology Advanced Radiometer (NISTAR). The Trump Administration wants to eliminate funding for these two "Earth-facing" (as opposed to Sun-facing) instruments, whose origin is traced to then-Vice President Al Gore.

Planetary Science: The Europa Mission

As explained in last year's fact sheet, one planetary science program – robotic exploration of Jupiter's moon Europa -- has particularly enthusiastic support from Rep. John Culberson (R-TX), who chairs the House Appropriations Commerce-Justice-Science (CJS) subcommittee that funds NASA. Some scientists are convinced that Europa has an ocean under its icy crust and conditions might be suitable for microbial life to develop. Culberson has said in many venues that he believes there is life in Europa's ocean and he is intent on funding spacecraft to find it.

Culberson has been adding substantial amounts to NASA's budget to develop a Europa mission even though NASA had no plans to do so. As discussed earlier, NASA generally follows the recommendations of Decadal Surveys and the most recent Decadal Survey for planetary science identified a series of missions aimed at returning a sample of Mars to Earth as its top priority for a large "flagship" program. A mission to Europa was listed second, primarily because of its high cost. The report left open the possibility that a lower cost Europa mission would be a higher priority if more funding than expected became available.

Project managers at the Jet Propulsion Laboratory (JPL) reformulated the mission to lower the cost and Culberson added the money. The mission, Europa Clipper, involves a spacecraft that will orbit Jupiter and make multiple flybys of Europa, some of them close to the surface. Fissures in Europa's icy surface allow material from the ocean to spew out and some scientists believe plumes rise above the surface to an altitude the spacecraft could reach.

Culberson put language in the FY2017 Consolidated Appropriations Act (P.L. 115-31) that Europa Clipper is to be launched in 2022 using NASA's new big rocket, the Space Launch System (SLS). Culberson also wants NASA to build a second spacecraft that could land on the surface and specified in law that it be launched by 2024 also on SLS.

NASA is building the flyby/orbiter, but does not guarantee it will be ready by 2022. It is not building the lander. In its FY2019 budget request, it states that a Europa mission cannot be launched on SLS before 2025 without disrupting its human exploration plans. It includes $434 million in the program's cost estimate to purchase a commercial launch on a different rocket, noting that new commercial rockets may become available and the cost could be lower.

© Space and Technology Policy Group, LLC. All Rights Reserved.

The proposal to build Europa Clipper on a slower schedule and launch it on a rocket other than SLS is controversial. As discussed above, NASA may change its planning for this mission if a second SLS Mobile Launch Platform is built.

Office of Education

Like the Earth science programs above, the Trump Administration proposed eliminating NASA's Office of Education and the four programs it administers last year. Congress rejected the proposal to eliminate the programs, although it did not specify if the Office of Education itself had to continue. The Trump Administration again is proposing elimination of both in FY2019.

As explained in last year's fact sheet, NASA funds education activities both through its Office of Education and as part of science missions in the Science Mission Directorate (SMD). Generally speaking, these efforts are part of an effort to encourage students to study Science, Technology, Engineering and Math (STEM) fields, which has been supported on a bipartisan basis in the White House and Congress for many years.

Programs within NASA's Office of Education are very popular in Congress. Many expect it to restore funding for these programs when it completes action on the FY2019 budget request as it did last year.

NASA Budget and Agency Reorganization

The FY2019 budget request also reveals that NASA wants to reorganize its budget accounts and agency structure. The proposal eliminates NASA's Space Technology Mission Directorate (STMD), created by the Obama Administration to focus more attention on developing new technologies that are not mission-specific. It merges whatever will remain of that work with technology development in the Human Exploration and Operations Mission Directorate.

The new budget accounts are shown in Tables 1 and 2. The Space Technology account is eliminated, and the Exploration and Space Operations accounts are remixed into three new accounts:

- **Deep Space Exploration Systems**, which combines much of what was in the old Exploration account (SLS, Orion, Exploration Ground Systems) with Advanced Exploration Systems, including new activities associated with the Moon goal;
- **Exploration Research and Technology**, combining what remains of STMD plus Exploration Research and Development activities that were under Exploration; and
- **LEO and Space Flight Operations**, combining what previously was in the Space Flight Operations account plus the new Commercial LEO Development line item to help commercial companies building LEO infrastructure.

In an unmistakable symbolic change, all three human exploration accounts now are listed ahead of science, which has been first since FY2004.

NASA plans to reorganize the human space flight management structure of the agency as well. STMD Associate Administrator Steve Jurczyk was promoted to be NASA's Acting Associate

© Space and Technology Policy Group, LLC. All Rights Reserved.

Administrator (the highest ranking civil servant at the agency). He has been tasked with making a recommendation on the new organization.

CONGRESSIONAL ACTION

NASA Authorization Bill

The House Science, Space, and Technology (SS&T) Committee approved a FY2018-2019 NASA authorization bill, H.R. 5503, on April 17, 2018. Authorization bills set policy and recommend funding levels, but do not actually provide any money. **Only appropriations bills provide money.** However, the authorization funding recommendations are tracked in Table 1 below since they represent the views of the authorization committees and can influence appropriators. In total, the bill authorizes $21.207 billion, $1.315 billion more than the request.

On the policy issues discussed in this report, the bill takes the following positions:

- **Moon/Mars.** Supports the plan in the budget request and authorizes more funding than requested for SLS, Orion and the associated ground systems, including funding for a second Mobile Launch Platform. Directs NASA to continue planning to get humans to land on Mars no later than 2033.
- **ISS Transition.** States that NASA shall operate ISS "for such time as Congress authorizes" rather than specifying a year as it has in the past (the 2017 authorization act says "at least until 2024"). Takes a wait and see attitude towards the Transition Plan noting "the feasibility of ending direct NASA support for ISS operation by the end of fiscal year 2024 is dependent on many factors some of which are indeterminate until the Administration carries out the initial phases of the ISS transition plan."
- **Astrophysics and WFIRST Cancellation**. Takes a wait and see attitude regarding WFIRST, saying there is insufficient information on which to make a decision. If WFIRST does proceed, the cost would be capped at $3.2 billion and NASA is prohibited from procuring a launch vehicle for it until JWST is operational. The bill adds $180 million for astrophysics to cover any additional required funding for JWST and $10 million for NASA to partner with private sector and philanthropic organizations to search for "technosignatures," such as radio transmissions, that could indicate the presence of intelligent life.
- **Earth Science.** The draft bill that was presented for mark up on April 17, 2018 would have cut another $334 million from Earth science on top of the reduction proposed by the President. That would have meant a total reduction of $471 million from FY2018 to FY2019. This prompted strong partisan debate during the markup. Ultimately, the committee agreed to restore the entire $471 million so the bill could be approved with bipartisan support. Thus, FY2019 funding would be the same as FY2018: $1.921 billion
- **Planetary Science/Europa.** The bill authorizes $2.637 billion for planetary science, an increase of $402 million above the request of $2.235 billion (compared to FY2018 funding of $2.228 billion). It does not mention Europa specifically.
- **Education.** The bill rejects the proposal to eliminate funding for the four education programs and authorizes $100 million, the same amount appropriated in FY2018.
- **Agency Reorganization**. The bill adopts NASA's new budget structure and plan to eliminate STMD.

© Space and Technology Policy Group, LLC. All Rights Reserved.

More information about the bill is in two articles posted on SpacePolicyOnline.com: Draft NASA Authorization Bill – Wait and See on ISS Transition, WFIRST (April 15, 2018) and NASA Authorization Bill Clears Committee With Bipartisan Support After Last Minute Negotiations (April 17, 2018)

FY2019 NASA Appropriations

The House Appropriations Commerce-Justice-Science (CJS) subcommittee approved its version of the FY2019 CJS bill on May 9, 2018 and the full committee approved the bill on May 17 with no changes to the NASA portion. The bill recommends $21.546 billion for NASA, an increase of $1.654 billion above the request and $810 million over NASA's FY2018 spending level.

On the issues highlighted in this report, the bill takes the following actions as explained in the bill or its accompanying report.

- **Moon/Mars.** The committee "fully funds the Moon exploration initiatives requested throughout NASA," but limits obligation of the funds "until a multi-year plan, with specific goals and funding requirements by fiscal year, is submitted to the Committee." It views the lunar projects as "risk reduction activities toward human exploration of Mars." The bill funds SLS, Orion and EGS at their FY2018 levels, which is more than requested, and the Lunar Orbital Platform-Gateway at its requested level ($504 million). The bill adds $150 million to the Advanced Exploration Systems subaccount under Deep Space Exploration Systems (DSES). That is for the Human Research Program (with an increase of $10 million over the $140 million request), which NASA wanted to place in the Exploration Research and Technology (ER&T) account. The committee chose to place it in DSES instead, so it appears as an increase in DSES and a decrease in ER&T.
- **ISS Transition.** The committee "reiterates that the International Space Station shall remain operational as long as its remains safe and operable."
- **Astrophysics.** WFIRST is funded at $150 million, the same as FY2018 and about half of what NASA projected last year would be needed in FY2019 to keep the project on schedule. The committee expresses concern about growing costs, but directs NASA to continue with the coronagraph and specifies that $20 million of that amount is for the Starshade technology demonstration. The James Webb Space Telescope remains capped at $8 billion for development and NASA must inform Congress if that will be breached (which NASA already has done). The committee says the JWST schedule slips are "an enormous disappointment." The committee kept JWST in a separate subaccount rather than merging it with the rest of astrophysics to "ensure visibility" as the program deals with the delays and expected cost growth.
- **Earth Science.** Funds Earth science at $1.9 billion, $523.5 million more than requested, and $21 million less than FY2018. The bill and report do not address the proposed cancellations of PACE, CLARREO-Pathfinder, OCO-3 or the DSCOVR Earth-facing instruments.
- **Planetary Science/Europa.** Funds planetary science at $2.756 billion, which is $523.5 million above the request and $539 million more than FY2018. It more than doubles the amount of funding for the Europa Clipper mission ($545 million compared to the $265 million requested) and adds $195 million for the lander (none was requested). It

© Space and Technology Policy Group, LLC. All Rights Reserved.

continues to insist that Clipper be launched in 2022 and the lander in 2024. The report also specifies $210 million for developing technology for planetary missions, including $35 million for icy satellites surface technology, $10 million for the Mars helicopter for the Mars 2020 mission (which itself is funded at $650 million), and $81 million (as requested) for production of plutonium-238 for use in radioisotope power sources for planetary missions.

- **Education.** The bill provides $90 million, compared to the zero requested, allocated as follows: Space Grant, $40 million; EPSCoR, $18 million; and MUREP, $32 million.
- **Agency Reorganization.** The bill generally adopts the new budget structure NASA proposed for the human exploration program and the abolition of the Space Technology Mission Directorate. It does not, however, move human exploration ahead of science and aeronautics as the Administration proposed (a symbolic move to underscore that it considers human exploration to be NASA's core mission). As noted above, the committee also did not agree to put the Human Research Program into the Exploration Research & Technology account, choosing to keep it with SLS and Orion in Deep Space Exploration Systems because it sees synergies among those programs and separating them "may introduce unnecessary risk." The committee also keeps JWST in its own subaccount under the Science Mission Directorate, rather than merging it with the rest of astrophysics, to "ensure visibility."

While the committee is very generous to NASA, it also included some cautionary notes.

- The cost increases and schedule delays for both human and robotic missions are "intolerable and must not continue."
- Although supportive of the new focus on the Moon, "these programs must not exhaust funding for other science priorities recommended by the National Academies Decadal Survey process."
- NASA must submit "realistic outyear budgets" and "refrain from submitting budgets that are not executable in a timely fashion, as they serve only to hinder efficient long-term planning which in turn results in higher overall program costs."
- NASA must execute its budget as directed and "is reminded that comity has existed between the Congress and the Executive Branch with respect to abiding by language included in this report and in the accompanying bill. The Committee expects NASA to respect this long-standing practice."

© Space and Technology Policy Group, LLC. All Rights Reserved.

Table 1: NASA's FY2019 Budget Request (in NASA's new account format)

(in $ millions, see notes below)

				Authorization			Appropriations		
Account (note 3)	**F2017 Op Plan**	**FY2018 Note 4**	**FY2019 Request**	**House Cmte**	**Senate**	**Final**	**House Cmte**	**Senate**	**Final**
Deep Space Expl Syst	**4,184.0**	**Note 4**	**4,558.8**	**4,929.0**			**5,083.9**		
Expl Sys Dev	*3,929.0*	*4,045.0*	*3,669.8*	*4,040.0*			*4,045.0*		
(Orion)	*(1,330.0)*	*(1,350.0)*	*(1,163.5)*	*(1,350.0)*			*(1,350.0)*		
(SLS)	*(2,127.1)*	*(2,150.0)*	*(2,078.1)*	*(2,150.0)*			*(2,150.0)*		
(Expl Grnd Sys)	*(471.9)*	*(545.0)*	*(428.2)*	*(540.0)*			*(545.0)*		
Adv Expl Sys	*97.8*	*Note 4*	*889.0*	*889.0*			*1,038.9*		
(Lunar Orb Pl-Gtway)	*N/A*	*N/A*	*(504.2)*	*(504.3)*			*(504.0)*		
(Cislunar/Surf Capblty)	*N/A*	*N/A*	*(116.5)*	*(116.5)*			*(116.5)*		
(Expl Adv Sys)	*97.8*	*Note 4*	*(268.2)*	*(268.2)*			*Note 5*		
(Human Rsrch Prog)	--	--	--	--			*Note 5 (150.0)*		
Expl Res & Dev	*157.2*	*395.0*	*N/A*	*N/A*			*N/A*		
Expl Res & Tech	**826.5**	**Note 4**	**1,002.7**	**1,017.7**			**Note 5 900.0**		
LEO & Spcflt Ops	**4,942.5**	**4,751.5**	**4,624.6**	**4,624.6**			**4,624.7**		
ISS	*1,450.9*	*N/A*	*1,462.2*	*1,462.2*			*Not specified*		
Space Trans (for ISS)	*2,589.0*	*N/A*	*2,108.7*	*2,108.7*			*Not specified*		
Space & Flt Spprt	*902.6*	*N/A*	*903.7*	*903.7*			*Not specified*		
Cmrcl LEO Developmnt	*N/A*	*N/A*	*150.0*	*150.0*			*150.0*		
Science	**5,762.2**	**6,221.5**	**5,895.0**	**6,623.6**			**6,680.6**		
Earth Science	*1,907.7*	*1,921.0*	*1,784.2*	*1,921.0*			*1,900.0*		
Planetary	*1,827.5*	*2,227.9*	*2,234.7*	*2,636.5*			*2,758.5*		
Astrophysics (incl JWST)	*1,352.3*	*1,384.1*	*1,185.4*	*1,375.4*			*1,029.0*		
JWST (separately)	--	--	--	--			*304.6*		
Heliophysics	*674.7*	*688.5*	*690.7*	*690.7*			*688.5*		
Aeronautics	**656.0**	**685.0**	**633.9**	**685.0**			**715.0**		
Education	**100.0**	**100.0**	**0.0**	**100.0**			**90.0**		
Safety, Security, MS	**2,768.6**	**2,826.9**	**2,749.7**	**2,749.7**			**2,850.0**		
CECR	**375.6**	**562.2**	**388.2**	**438.2**			**562.2**		
Inspector General	**37.9**	**39.0**	**39.3**	**39.3**			**39.3**		
TOTAL	**19,653.3**	**20,736.1**	**19,892.2**	**21,207.1**			**21,545.7**		

© Space and Technology Policy Group, LLC. All Rights Reserved.

Note 1: Source: NASA FY2019 budget documentation and congressional bills and reports. Columns may not add due to rounding. Text and numbers in *italics* are subtotals. Text and numbers in (*italics in parentheses*) are sub-subtotals. N/A = not applicable or not available.
Note 2: Op Plan – Operating Plan. CECR = Construction and Environmental Compliance and Restoration.
Note 3: NASA reconfigured its budget accounts in its FY2019 request and plans to reorganize the agency mission directorates as well. That includes eliminating the Space Technology Mission Directorate (STMD) and merging its functions with certain portions of the Human Exploration and Operations Mission Directorate. Hence, the "Space Technology" account no longer appears in the budget request. It has been merged with portions of the Exploration budget and they are now "Exploration Research and Technology." "Space Operations" is renamed "LEO and Space Flight Operations." "Exploration" is renamed "Deep Space Exploration Systems." Also, the James Webb Space Telescope previously had its own budget line, but now is merged with the rest of astrophysics. In a symbolic change, all the human exploration accounts now come before science, which used to be first. This table displays the request in NASA's new format. Thus, it is difficult to compare NASA's prior year budgets with this year's request. Congress ultimately will decide whether or not to accept the new structure. If it does not, this table will be replaced with whatever Congress determines to be appropriate.
Note 4: NASA changed its budget structure for FY2019 making comparisons with prior years problematical. In this table, where possible the comparable numbers for final FY2018 appropriations are included based on the FY2018 Consolidated Appropriations Act and accompanying explanatory statement. The new accounts for human spaceflight are not represented there, of course. We have requested the data from NASA, but it was not available as of the date of this report. **These figures do not include $81 million in emergency supplemental appropriations that were provided for disaster relief following Hurricanes Harvey and Irma in 2018.**
Note 5: The House Appropriations Committee decided not to move the Human Research Program (HRP) into the Exploration Research and Technology (ER&T) account as requested. Instead it is part of Deep Space Exploration Systems (DSES). Thus, the amount for ER&T is less than the request and the DSES subaccount "Advanced Exploration Systems" (AES) is increased by the $150 million the committee allocates for HRP ($10 million above the request). The committee is NOT clear whether the $150 million it allocates for HRP is a separate subaccount within AES, or part of an existing AES subaccount with a very similar name "Exploration Advanced Systems" (EAS). The report does not specify the total for EAS although arithmetic yields the answer $268.2 million, which is the same as the request, if HRP is not added to it.

© Space and Technology Policy Group, LLC. All Rights Reserved.

Table 2: Projected NASA Budget FY2019-2023 (Out-Years)
(in $ millions)

Account	President's Request	Notional			
	FY2019	FY2020	FY2021	FY2022	FY2023
Deep Space Expl Syst	**4,558.8**	**4,859.1**	**4,764.5**	**4,752.5**	**4,769.8**
Expl Sys Dev	*3,669.8*	*3,790.5*	*3,820.2*	*3,707.5*	*3,845.6*
(Orion)	*(1,163.5)*	*(1,137.7)*	*(1,134.2)*	*(1,117.8)*	*(1,117.8)*
(SLS)	*(2,078.1)*	*(2,062.9)*	*(2,165.1)*	*(2,131.0)*	*(2,276.0)*
(Expl Grnd Sys)	*(428.2)*	*(589.9)*	*(520.8)*	*(458.7)*	*(451.9)*
Adv Expl Sys	*889.0*	*1,068.6*	*944.3*	*1,045.0*	*924.1*
(Lunar Orb Pl-Gtway)	*(504.2)*	*(662.0)*	*(540.0)*	*(558.9)*	*(459.1)*
(Cislunar/Surf Capblty)	*(116.5)*	*(146.0)*	*(163.7)*	*(300.0)*	*(320.3)*
(Expl Adv Sys)	*(268.2)*	*(260.7)*	*(240.6)*	*(186.1)*	*(144.7)*
Expl Res & Dev	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Expl Res & Tech	**1,002.7**	**912.7**	**912.7**	**912.7**	**912.7**
LEO & Spcflt Ops	**4,624.6**	**4,273.7**	**4,393.3**	**4,430.3**	**4,438.0**
ISS	*1,462.2*	*1,453.2*	*1,471.2*	*1,466.2*	*1,451.2*
Space Trans (for ISS)	*2,108.7*	*1,829.1*	*1,858.9*	*1,829.2*	*1,807.3*
Space & Flt Spprt	*903.7*	*841.4*	*888.2*	*934.9*	*954.6*
Cmrcl LEO Developmnt	*150.0*	*150.0*	*175.0*	*200.0*	*225.0*
Science	**5,895.0**	**5,859.9**	**5,841.1**	**5,822.4**	**5,803.6**
Earth Science	*1,784.2*	*1,784.2*	*1,784.2*	*1,784.2*	*1,784.2*
Planetary	*2,234.7*	*2,199.6*	*2,180.8*	*2,162.1*	*2,143.3*
Astrophysics (incl JWST)	*1,185.4*	*1,185.4*	*1,185.4*	*1,185.4*	*1,185.4*
Heliophysics	*690.7*	*690.7*	*690.7*	*690.7*	*690.7*
Aeronautics	**633.9**	**608.9**	**608.9**	**608.9**	**608.9**
Education	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Safety, Security, MS	**2,749.7**	**2,744.8**	**2,738.6**	**2,732.3**	**2,726.1**
CECR	**388.2**	**293.8**	**293.8**	**293.8**	**293.8**
Inspector General	**39.3**	**39.3**	**39.3**	**39.3**	**39.3**
TOTAL	**19,892.2**	**19,592.2**	**19,592.2**	**19,592.2**	**19,592.2**

Notes: Source: NASA FY2019 budget documentation. Columns may not add due to rounding. Text and numbers in *italics* are subtotals. Text and numbers in (*italics in parentheses*) are sub-subtotals. N/A = not applicable. CECR = Construction and Environmental Compliance and Restoration

© Space and Technology Policy Group, LLC. All Rights Reserved.

APPENDIX A

NASA's OBJECTIVES AS STATED IN THE 1958 NATIONAL AERONAUTICS AND SPACE ACT, AS AMENDED (51 U.S.C. §20102)

d) Objectives of Aeronautical and Space Activities.—The aeronautical and space activities of the United States shall be conducted so as to contribute materially to one or more of the following objectives:

(1) The expansion of human knowledge of the Earth and of phenomena in the atmosphere and space.

(2) The improvement of the usefulness, performance, speed, safety, and efficiency of aeronautical and space vehicles.

(3) The development and operation of vehicles capable of carrying instruments, equipment, supplies, and living organisms through space.

(4) The establishment of long-range studies of the potential benefits to be gained from, the opportunities for, and the problems involved in the utilization of aeronautical and space activities for peaceful and scientific purposes.

(5) The preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere.

(6) The making available to agencies directly concerned with national defense of discoveries that have military value or significance, and the furnishing by such agencies, to the civilian agency established to direct and control nonmilitary aeronautical and space activities, of information as to discoveries which have value or significance to that agency.

(7) Cooperation by the United States with other nations and groups of nations in work done pursuant to this chapter and in the peaceful application of the results thereof.

(8) The most effective utilization of the scientific and engineering resources of the United States, with close cooperation among all interested agencies of the United States in order to avoid unnecessary duplication of effort, facilities, and equipment.

(9) The preservation of the United States preeminent position in aeronautics and space through research and technology development related to associated manufacturing processes.

(10) The search for life's origin, evolution, distribution, and future in the universe.

When the law was enacted in 1958, there were eight objectives. The original text of the Act is available at this link. In summary, over the past six decades the following changes were made: Objective 1 was modified by adding "of the Earth and"; Objective 7 was modified to state "in this chapter" instead of "in this Act" because the Act was incorporated into the U.S. Code as chapter 51; and Objectives 9 and 10 were added.

© Space and Technology Policy Group, LLC. All Rights Reserved.