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Committee on Science, Space, and Technology

EXAMINING NASA'S PLANS FOR THE INTERNATIONAL SPACE STATION AND FUTURE ACTIVITIES IN LOW EARTH ORBIT

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Chairwoman Horn, Ranking Member Babin, and Members of the Subcommittee:

The Office of Inspector General (OIG) is committed to providing independent, aggressive, and objective oversight of NASA. We welcome this opportunity to discuss the Agency's challenges and opportunities for fully utilizing the International Space Station (ISS or Station) at least through 2024 while spurring commercialization activities in low Earth orbit.¹

Over the past 5 years, the OIG has issued 13 reports related to the ISS, including reviews on NASA's efforts to maximize research, extend its operations, manage contracts with private companies to fly cargo and crew to the Station, and maintain international partnerships that fund close to one-quarter of the Station's annual expenses. My testimony today is informed by each of these past reports, but primarily draws on our July 2018 audit examining NASA's plans for maximizing ISS utilization, including extension of ISS operations beyond the end of fiscal year (FY) 2024 and the necessity to safely dispose of the Station once it is no longer in use.² In that report, we also touched on the Administration's stated goal of transitioning the ISS to private operation beginning in FY 2025 and raised concerns about the significant challenges NASA faced in stimulating adequate private sector interest in this endeavor.

For the past 21 years, the ISS has served as a platform for humans to learn about living and working in space. NASA's original vision was that astronauts living on the Station would conduct biological and materials research, demonstrate American leadership in space, forge international cooperation, and lead efforts to commercialize low Earth orbit. To its credit, the Agency has accomplished many of these goals over the past two decades. NASA has sponsored research aboard the ISS in the areas of life and physical sciences; human health; astrophysics; Earth sciences; space science; and commercial research and development for pharmaceuticals, materials, manufacturing, and consumer products. The ISS has also been used in disaster response on Earth by providing near real-time mapping support for recovery and humanitarian aid efforts. However, all of these achievements have come at a cost of \$3 to \$4 billion annually or about half of the Agency's human space flight budget.³ Moreover, any decision regarding extending NASA's activities in low Earth orbit needs to be considered in tandem with the Agency's efforts to achieve a lunar landing mission by 2024.⁴

Against this backdrop, the President's FY 2020 budget request for NASA envisions new commercial capabilities on the ISS by 2025 as well as new commercial facilities and platforms in low Earth orbit. Further, NASA recently announced plans to host private astronauts on the ISS and provide a range of capabilities for private researchers beginning as soon as 2020. These developments are a marked change from the proposal in NASA's FY 2019 budget request to end direct federal funding for the ISS beginning in 2025 and provide a more incremental approach to commercializing ISS operations. In our July 2018 report, we found the Station will require significant federal funding beyond 2025 to continue

¹ The ISS is currently authorized to continue operations through September 30, 2024. Legislation introduced in the Senate would extend that authorization through 2030.

² NASA OIG, *NASA's Management and Utilization of the International Space Station* (IG-18-021, July 30, 2018).

³ In the President's FY 2020 budget request, the ISS budget included approximately \$1.8 billion for crew and cargo transportation, \$1.1 billion for systems operations and maintenance, and \$353 million for research.

⁴ In March 2019, the Vice President stated that the Administration was committed to landing humans on the Moon by 2024, 4 years sooner than planned in the President's FY 2020 budget request. In May 2019, NASA submitted a budget amendment requesting an increase of \$1.6 billion above the President's initial \$21 billion FY 2020 budget request for the Agency as a "down payment" to meet that goal. Designated the Artemis Program, in June 2019 the Administrator said NASA would need \$20 to \$30 billion in addition to current Agency appropriations over the next 5 years—an average of an additional \$4 to \$6 billion per year—to put the first woman and next man on the Moon by 2024.

operations and maintenance given the current limited commercial market interested in assuming the ISS's operational costs. Although we have yet to review in-depth the Agency's new plans, the approach appears more realistic by seeking to maximize utilization of the ISS under the current government-funded model while providing incremental opportunities for commercialization. We plan to examine NASA's evolving strategies for ISS commercialization as the Agency further develops its plans.

Continuing Utilization of the ISS

In March 2017, Congress directed NASA to submit an ISS Transition Report detailing the impact that extending the service life of the ISS beyond 2024 would have on its deep space exploration capabilities.⁵ Although the ISS is currently authorized to operate through September 2024, several legislative proposals would extend Station operations through at least 2030.⁶ NASA is close to completing its evaluation of the feasibility of extending the Station's service life through at least 2028 with The Boeing Company (Boeing), NASA's prime ISS contractor, certifying to date all major U.S. structural elements to 2028 with the exception of an external stowage platform and six truss segments, which the Agency expects to be completed by late December 2019. In addition, Boeing assessed and cleared to 2028 critical operational capabilities including electrical power, environmental control and life support, and thermal control. As NASA noted in its Transition Report, based on structural integrity analyses the ISS platform has significant structural life well beyond 2028 and many of its modules, particularly those launched in the latter years of ISS assembly, are likely to have structural life well into the 2030s.

Our July 2018 audit highlighted the significant funding required to operate and maintain the Station as one of the biggest challenges to continuing ISS operations past 2024, at least under the current funding model.⁷ Congress directed the Agency to include in its ISS Transition Report "the impact on deep space exploration capabilities, including a crewed mission to Mars in the 2030s, if the preferred service life of the ISS is extended beyond 2024 and NASA maintains a flat budget profile."⁸ Despite this directive, the ISS Transition Report is silent on this issue. Nonetheless, in previous work we have found that extension of the Station's service life beyond 2024 will continue to require \$3 to \$4 billion per year. This amount is currently about half of NASA's annual human space flight budget and therefore directly impacts the Agency's ability to fund components NASA has deemed necessary for its deep space exploration goals including the Space Launch System, Orion Multi-Purpose Crew Vehicle, Lunar Gateway, lunar landers, and spacesuit development unless NASA receives a marked and sustained increase in funding.⁹

⁵ National Aeronautics and Space Administration Transition Authorization Act of 2017, Pub. L. No. 115-10, 131 Stat. 28 (2017).

⁶ 51 U.S.C. § 70907(a)(3). In February 2019, the Senate Committee on Commerce, Science, and Transportation introduced S. 584, Advancing Human Spaceflight Act, which would authorize the ISS through 2030, direct NASA to develop a next-generation spacesuit to enable human exploration beyond low Earth orbit, and establish the goal of a permanent human presence beyond Earth as national policy. In March 2019, the Committee also introduced S. 919, Space Frontier Act of 2019, which would also authorize the ISS through 2030 and includes a provision to streamline and update regulation of commercial space launch services and commercial satellite remote sensing.

⁷ IG-18-021.

⁸ Pub. L. No. 115-10 § 303 (c), 131 Stat. 28.

⁹ The Lunar Gateway is envisioned as a small space station in orbit around the Moon that will contain living quarters for astronauts, a laboratory for science and research, and ports for visiting spacecraft in support of both human and robotic missions. NASA sees the Gateway as the home base for astronaut expeditions on the Moon and future human missions to Mars. NASA plans to build a scaled-down version of the Gateway in time for a 2024 Moon landing consisting of a Power and Propulsion Element (scheduled to launch in 2022) and a small living space with science and operational capabilities.

Balanced against the expense, an extension to 2028 or beyond would enable NASA to continue critical on-orbit research into human health risks and demonstrate the technologies that will be required for future missions to the Moon and Mars. At this time, NASA forecasts that research for at least 6 of 20 human health risks requiring the ISS for testing and 2 of 37 technology gaps will not be completed by the end of September 2024 when the Station's current authorization to operate expires. In addition, research into 2 other human health risks and 2 additional technology gaps is not scheduled to be completed until sometime in 2024, meaning that even minor schedule slippage could push completion past the end of that fiscal year.

While NASA may be able to find alternative, ground-based or Lunar Gateway testing options for certain health risks and technology demonstrations, Agency officials have stressed that research into other areas will continue to require the Station's unique, long-duration microgravity environment. In July 2018, we reported that although NASA has generally met or exceeded its goal of 35 hours per week dedicated to research aboard the ISS, the amount of crew time available for research continues to be a major factor limiting greater utilization on-orbit given that many investigations require participation by the crew in some capacity, particularly human health research.¹⁰ If the remaining health risks and technology demonstrations cannot be fully tested on the ISS, NASA may have to accept higher levels of risk than planned for future exploration missions.

Delays in commencement of commercial crew transportation capabilities likely will result in significant decreases in research conducted on the ISS.¹¹ If commercial transportation is delayed beyond February 2020, there is a risk the U.S. portion of the ISS could be forced to operate with only 2 crew members or possibly just a single crew member beginning in April. This reduction in crew will significantly decrease the amount of on-board scientific research because Station crew will need to focus mainly on visiting spacecraft operations and ISS maintenance. NASA has several key technology demonstrations planned for 2020 required for deep space exploration including water processing and fire containment, research that could be compromised by a reduction in crew. To help mitigate the risk of limited crew availability, the Agency is implementing a recommendation from our July 2018 report to develop plans for additional one-year astronaut missions to the ISS.

In April 2017, we reported on NASA's development of new spacesuits, another key technology demonstration project that will utilize the Station's microgravity environment.¹² The Shuttle-era spacesuits NASA astronauts currently use on the Station need to be replaced due to aging and attrition, and the Agency expects a demonstration unit of the replacement suits to be delivered to the ISS for testing in 2023. Our 2017 report highlighted a number of current spacesuit design inadequacies and

¹⁰ IG-18-021.

¹¹ Since NASA's Space Shuttle was retired in 2011, the Russian Soyuz spacecraft has been the only vehicle capable of transporting crew to the ISS. NASA's contract for seats on the Soyuz to transport U.S. astronauts to the ISS ensures access to the Station through early 2020. As the Government Accountability Office (GAO) reported in January 2018, delays in the development and certification of commercial crew vehicles could result in these vehicles not being available to ferry crew to the ISS before NASA's current contract for Soyuz seats ends. Therefore, if commercial crew providers are not ready by that time and NASA is unable to purchase additional Soyuz seats, NASA could face a gap in its access to the ISS thereby limiting crew availability. GAO, *NASA Commercial Crew Program: Continued Delays Pose Risks for Uninterrupted Access to the International Space Station* (GAO-18-317T, January 17, 2018).

¹² NASA OIG, *NASA's Management and Development of Spacesuits* (IG-17-018, April 26, 2017).

health risks that NASA continues to manage, including the limited number of sizes available.¹³ This issue was brought to the forefront 4 months ago when NASA planned, but was not able to execute, its first all-female spacewalk because both women required the same size hard upper torso but only one such unit was available. The replacement spacesuits are designed to address many of the inadequacies and health risks posed by the current spacesuit and are planned for use on the ISS, Lunar Gateway, and ultimately in support of a Moon landing.

Research managed by the Center for the Advancement of Science in Space (CASIS) also contributes to NASA's ability to fully utilize the ISS. Since August 2011, CASIS has managed non-NASA research activities—those performed by commercial companies, academia, and other government and non-government entities—on the U.S. portion of the ISS known as the National Laboratory (National Lab). NASA initially awarded CASIS a 10-year, \$136 million cooperative agreement to manage, develop, and stimulate interest and use of the National Lab. In July 2017, the Agency extended the CASIS cooperative agreement to September 2024, increasing its total cost to \$196 million.

However, since 2013 we have raised concerns about CASIS's performance and its ability to spur ISS research; specifically, we found that fostering a commercial interest in ISS-based research and recruiting users for the National Lab has proven to be a significant challenge for CASIS.¹⁴ In particular, CASIS had difficulty attracting commercial companies because ISS research costs were significantly higher than ground-based research. In January 2018, we reported that CASIS had not met a majority of the expectations set out in its cooperative agreement with NASA and the organization had underperformed on tasks important to achieving NASA's goal of building a commercial space economy in low Earth orbit.¹⁵ In that report, we also found that NASA shared responsibility for CASIS's failure to meet expectations because the Agency did not actively oversee the organization's technical performance and generally allowed CASIS to operate independently.

In the 18 months since we issued our January 2018 report, NASA and CASIS have reported improvement in both oversight and performance. Specifically, in support of closing six of the seven recommendations from that audit, CASIS increased staffing in areas critical to business development; implemented an on-line Implementation Partner Portal; and made improvements to the implementations partner selection process to improve transparency, fair and open competition, and protection of partner proprietary data. NASA also has established measurable metrics in the CASIS annual program plan and provided CASIS management with constructive, regular feedback. In its FY 2018 Annual Report, CASIS reported a record year including \$150 million in external, non-NASA funding to support its portfolio, a 50-percent increase over FY 2017, and the strongest year for growing its research and development portfolio by selecting 50 new projects. However, as NASA reiterated in its June 2019 feedback to CASIS, sustained focus on exceeding metrics, increasing available seed funds, managing administrative costs, finding and developing new users for the National Lab, and improving mechanisms to foster business-to-business relationships are required to expand commercialization in low Earth orbit and maximize utility of the ISS.

¹³ Developed beginning in 1974 and first flown in 1981, the spacesuits currently aboard the ISS were originally designed for the Space Shuttle Program during a time when the astronaut corps was not as diverse in size as they are now. Over the last 40 years, each suit has been partially redesigned and completely refurbished multiple times, but the sizes available include only medium, large, and extra-large.

¹⁴ NASA OIG, *NASA's Efforts to Maximize Research on the International Space Station* (IG-13-019, July 8, 2013).

¹⁵ NASA OIG, *NASA's Management of the Center for the Advancement of Science in Space* (IG-18-010, January 11, 2018).

Commercialization Efforts on the ISS and in Low Earth Orbit

In addition to its work with CASIS, NASA has taken several concrete steps over the past decade to meet its goal of increasing commercialization of the ISS and low Earth orbit, the largest of which is supporting the commercial launch market by introducing competition and developing new domestic capabilities. In April 2018, we reported that through 2017 NASA had awarded \$17.8 billion towards development of commercial launch vehicles and spacecraft to deliver cargo and crew to and from the ISS through 2024.¹⁶ This funding—more than \$9 billion for cargo delivery and over \$8 billion for development of a crew transportation capability to deliver astronauts to the ISS—helped pay for development of two launch vehicles, four spacecraft for cargo deliveries, and two spacecraft for crew transportation. These cargo and crew transportation efforts represent NASA’s most significant investment in the commercialization of low Earth orbit.

As part of NASA’s vision to commercialize ISS activities and low Earth orbit, the Agency is considering a range of options to subsidize commercial partners to foster development of a private market while maintaining funding to the ISS. These options include augmenting the Station with privately developed modules, combining portions of the current platform with a new private platform, and deploying an entirely new free-flying platform that will allow NASA to retire and deorbit the ISS. NASA also recently announced a commercialization policy to allow private astronauts and commercial and marketing activities on the ISS.¹⁷ In addition, NASA is assessing whether its long-term research requirements, which are similar to those of the current ISS Program, could be met with platforms or modules that do not require a vehicle as complex and expensive to maintain as the ISS. In this way, NASA’s vision presents a more measured and incremental approach to commercialization that matches the responses the Agency received from private companies to last year’s request for commercialization studies, all of which indicated the commercial market needed substantial government support to be viable in the short-term.

In May 2018, before the Senate Subcommittee on Space, Science, and Competitiveness, I testified that NASA’s then-plan to privatize the ISS by the beginning of FY 2025 remained a controversial and highly debatable proposition, particularly with regard to the feasibility of fostering increased commercial activity in low Earth orbit by that time.¹⁸ Specifically, we questioned whether a sufficient business case exists under which private companies can create a self-sustaining and profit-making business independent of significant government funding. In particular, I stated that it is unlikely a private entity or entities would assume the Station’s annual operating costs, which was projected at \$1.2 billion in 2024.¹⁹ Such a business case requires robust demand for commercial market activities like space tourism, satellite servicing, manufacturing of goods, and research and development, all of which have yet to materialize.

¹⁶ This does not include all cargo transportation costs through 2024. As of December 2017, NASA had to purchase at least 10 more missions to meet minimum order requirements, which in turn will increase the Agency’s funding beyond \$20 billion when those task orders are awarded. NASA OIG, *Audit of Commercial Resupply Services to the International Space Station* (IG-18-016, April 26, 2018).

¹⁷ See Introduction to ISS Commercial Use Policy, <https://www.nasa.gov/leo-economy/commercial-use/introduction-to-policy> (accessed July 3, 2019).

¹⁸ Examining the Future of the International Space Station. Before the Senate Subcommittee on Space, Science, and Competitiveness, 115th Congress (2018) (statement of NASA Inspector General Paul Martin).

¹⁹ NASA’s FY 2020 budget forecasts \$983.1 million will be needed in 2024 for Station operations.

Last month, NASA announced a new interim directive outlining use of the ISS for commercial and marketing activities.²⁰ The directive addresses manufacturing of goods on the ISS for commercial sale on Earth, hosting private astronauts on the Station, and allowing NASA astronauts to support commercial activities on the Station by allocating up to 5 percent of Station resources for these commercialization efforts. To reduce uncertainty and allow companies to develop business plans, NASA also published a pricing policy for delivery of cargo to and from the Station and the cost of resources available to private astronauts while on the ISS. For example, cargo prices range between \$6,000 and \$18,000 per kilogram round trip while NASA plans to charge around \$1 million for a one-month stay or about \$35,000 per day to host a private astronaut. This hosting cost does not include the expense of transporting the private astronaut to and from the ISS on a commercial launch vehicle. NASA acknowledges these prices are substantially subsidized—representing a small portion of NASA’s actual costs—but are another effort to foster a commercial market in low Earth orbit.

While all of these actions are positive steps, the effectiveness of NASA’s current plan to commercialize ISS operations while continuing to provide substantial Agency funding remains to be seen, particularly with regard to the feasibility of fostering increased commercial activity in low Earth orbit. Specifically, the new commercialization policy does not have performance metrics to evaluate how effectively NASA is nurturing commercial markets, although the Agency did agree with a recommendation we submitted during our review of the interim directive to add language establishing future metrics. Further, additional clarity may be needed on how to manage commercial mission and private astronaut requests and how their activities could impact commercial crew and cargo missions and crew capacity on the ISS. For example, the policy does not address pricing for commercial enterprises that may require shorter or longer timeframes than a 30-day mission. While the policy represents a more realistic and incremental approach than the original plan envisioned by the Agency’s FY 2019 budget request, the bottom line remains that NASA has struggled over the past 20 years to stimulate commercial interest on the ISS. Moreover, commercial entities have not developed a successful business case for manufacturing and other commercial activities in low Earth orbit, at least in the short or mid-term.

ISS International Partnerships Beyond 2024

Lastly, any discussion of the future of the ISS needs to consider the level of support from NASA’s current international partners—Russia’s Roscosmos space agency, the European Space Agency (ESA), the Canadian Space Agency, and Japan Aerospace Exploration Agency—whose continued participation hinges on issues ranging from international politics to differing space exploration goals. For example, the outlook for Russia’s continued involvement with the ISS is uncertain given the current state of relations between the two countries. Russia’s role is critical to sustaining ISS operations because it controls the Station’s propulsion system and propellant and is currently the only partner capable of providing crew transportation to and from the ISS. In addition, NASA’s exemption from the Iran, North Korea, Syria Nonproliferation Act (INKSNA) for ISS efforts expires on December 31, 2020, and failure to extend the Agency’s waiver would prohibit NASA from paying Roscosmos for services

²⁰ NASA Interim Directive 8600.121, *Use of International Space Station (ISS) for Commercial and Marketing Activities* (June 6, 2019).

performed on the Station after that point.²¹ Consequently, approval from Congress to further extend the exemption is required in order to maintain ISS operations as currently structured into the future.

The participation of NASA's other current international partners is also unsettled at this time given their desire to consider exploration missions beyond the ISS. For example, ESA has announced its intent to partner with NASA on the Lunar Gateway and other lunar activities. However, ESA and several other space agencies have also expressed interest in working with the Chinese Space Agency aboard its space station planned for operation in 2022.²² Given that NASA's current international partners are responsible for 23 percent of the Station's shared annual costs, the loss of one or more of these space agencies could have a significant impact on NASA's ability to sustain ISS operations past 2024.

Ultimately at some point, whether in an emergency or because its useful life has ended, NASA will need to decommission and deorbit the Station. Ideally, this will occur via a controlled, destructive reentry into the Earth's atmosphere. NASA estimates a controlled reentry of the ISS will take up to 3 years to execute and cost approximately \$950 million. However, the Agency has not completed the necessary tasks to execute such a deorbit. In January 2017, NASA completed a draft plan to address various deorbit scenarios and received and dispositioned comments from Roscosmos. As of July 2019, the Agency has received technical concurrence from all partners and is awaiting final Russian space agency programmatic concurrence. Although NASA engineers continue to work on the technical details of deorbit scenarios, the Agency presently does not have the capability to ensure a controlled deorbit of the ISS in the event of an emergency.

Conclusion

As NASA turns its attention to returning humans to the Moon by 2024, concrete plans for the future of the ISS need to be resolved. Whether it be extension, increased commercialization, or retirement, the timing of each of these decisions has a cascading effect on the funding NASA will be able to dedicate for space flight operations in low Earth orbit, its ambitions for establishing a permanent presence on the Moon, and ultimately sending humans to Mars. The sooner NASA, the Administration, and Congress agree on a definitive path forward for the future of the ISS, the better NASA will be able to plan the future of on-board research and commercialization in low Earth orbit.

²¹ The Iran Nonproliferation Act of 2000, Pub. L. No. 106-178, 114 Stat. 38 (2000) discouraged U.S. dealings with states that would proliferate nuclear materials to Iran and required the President to report payments made to Russia in connection with the ISS. The Iran Nonproliferation Amendments Act of 2005, Pub. L. No. 109-112, 119 Stat. 2366 (2005) amended the Iran Nonproliferation Act of 2000 to allow for unreported payments to Russia until 2016 for obligations under the Agreement Concerning Cooperation on the Civil International Space Station, signed on January 29, 1998, and entered into force March 27, 2001. The 2005 Act was also amended to apply to Syria as well as Iran. The North Korea Nonproliferation Act of 2006, Pub. L. No. 109-353, 120 Stat. 2015 (2006) amended this legislation to include North Korea and renamed the statute accordingly [hereinafter INKSNA]. The Space Exploration Sustainability Act, Pub. L. No. 112-273 (2013) amended INKSNA to extend NASA's exemption from reporting payments to Russia in connection with the ISS until 2020.

²² In March 2019, China announced it would begin construction of a new space station able to host up to three astronauts. In June 2019, the United Nations Office for Outer Space Affairs announced that 9 experiments had been selected for implementation aboard the Chinese space station representing work from 17 member states.