COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

HEARING CHARTER

America in Space: Future Visions, Current Issues

Wednesday, March 13, 2019
10:00 a.m.
2318 Rayburn House Office Building

PURPOSE

On Wednesday, March 13, 2019 the Committee on Science, Space, and Technology will hold a Full Committee hearing titled "*America in Space: Future Visions, Current Issues."* The purpose of the hearing is to provide big-picture perspectives on the future of the nation's civil space activities, including the roles of civil government and commercial entities, and to identify the key issues for the near term. The Committee will receive expert testimony on visions for science and inspiration, human exploration, and the international environment in which space exploration and utilization is carried out.

WITNESSES

- **Dr. Ellen Stofan** – John and Adrienne Mars Director, Smithsonian National Air and Space Museum, Former NASA Chief Scientist
- **Dr. Peggy A. Whitson** – Technical Consultant and Former Astronaut
- **Mr. Frank Rose** – Senior Fellow, Security and Strategy, The Brookings Institution, Former Assistant Secretary of State

BACKGROUND

Where will America's civil space program be in the next 10, 20 or 30 years? Multiple past advisory reports have considered this question. A sampling of those reports are listed and summarized in the following sections, as is background on how the space science community prioritizes its future goals. The civil space program is increasingly working in partnership with the growing commercial sector to leverage its capabilities. The state of the space economy and workforce also help enable the ability to carry out the nation's future visions for space. In addition, the geopolitical environment and the sustainability of the space environment itself are factors affecting the overall context in which the nation's future space activities and visions will be realized.

Reports on Visions and Future Directions

In 1989, twenty years after the Apollo 11 Moon landing, George H.W. Bush challenged the nation to send humans to Mars and return to the Moon en route to Mars. His Space Exploration Initiative was "a new vision for America in the 21st century." Six visions were to guide the Space Exploration Initiative: knowledge of our universe, advancement in science and engineering, United States leadership, technologies for Earth, commercialization of space, and strengthened U.S. economy. In response to a request by then Vice President Dan Quayle, **America at the Threshold: Report of the Synthesis Group on America's Space Exploration Initiative,** chaired by Lt. Gen. Thomas P. Stafford, USAF (ret.), outlined the rationale for implementing President G.H. Walker Bush's Space Exploration Initiative to send humans to the Moon and Mars and presented architectural options for achieving the initiative. (An architecture, as defined in the report, is "a set of objectives to achieve an overall capability…and the sequential series of missions to implement those objectives.") The architectures presented in the report were designed based on the desired emphasis on science and exploration, human presence, duration on the Moon, and space resource utilization. The report also discussed the supporting technologies, educational outreach, and programmatic actions needed to pursue the exploration goals. The report provided a roadmap for the Space Exploration Initiative and made recommendations for implementing actions.

America's Future in Civil Space: Proceedings of a Workshop[1]. In 2017, the National Academies of Sciences, Engineering, and Medicine convened a workshop to review what had changed, new opportunities, and how to inform implementation since the 2009 National Academies publication, **America's Future in Space: Aligning the Civil Space Program with National Needs[2]**. The chair of that study, Gen. Lester Lyles, USAF (ret.), summarized the recommendations of the 2009 report:

- "Space program capabilities should be aligned with high-priority national imperatives.
- NASA and the National Oceanic and Atmospheric Administration (NOAA) should lead the formation of an international satellite-observing architecture capable of monitoring global climate change and its consequences.
- NASA, in cooperation with other agencies and international partners, should continue to lead a program of scientific exploration and discovery.
- NASA should revolutionize its advanced technology development program.
- The government should pursue international cooperation in space as a means to advance U.S. strategic leadership and meet national and mutual international goals.
- NASA should be on the leading edge of actively pursuing human spaceflight."

While the 2017 workshop proceedings did not issue recommendations, key individuals summarized themes of the workshop discussions. Those themes included the view that:

- "The goals for our national civil space efforts from the 2009 America's Future in Space

[1] National Academies of Sciences, Engineering, and Medicine 2017. *America's Future in Civil Space: Proceedings of a Workshop in Brief*. Washington, DC: The National Academies Press. https://doi.org/10.17226/24921.
[2] National Research Council. 2009. *America's Future in Space: Aligning the Civil Space Program with National Needs*. Washington, DC: The National Academies Press. https://doi.org/10.17226/12701.

report are still largely valid today, although the environment in which we pursue those goals has changed.

- … the public knows little of the actual goals of our nation's space endeavors.
- … NASA remains a symbol of American leadership at home and around the world and can continue to be a tool of international policy, power, and diplomacy.
- Scientific discovery in our space program is transformational because it changes our collective perception of reality.
- The year 2028 is a key date for ISS [International Space Station] and will drive decisions and actions now, while there was also a strong message from a number of participants that we need to continue to plan for a NASA program that goes beyond ISS and beyond low Earth orbit. …
- New paradigms will also require the development of a new culture in NASA and the advancement of multigenerational teams while retaining institutional knowledge and expertise.
- The right motivation for partnering with private industry needs to be identified and then policies and incentives need to be established to bring industry into contributing to the public good at the core of the program under consideration. …
- Among what has stayed the same in recent years is that Mars has remained the horizon goal for exploration. What also has not changed is that NASA has too much on its plate and many constraints.
- What has changed includes new international actors in space—including an impressive space program from China. These new entrants and new industry players and new ways of doing business with established industry provide many new opportunities."

Pathways to Exploration: Rationales and Approaches for a U.S. Program of Human Space Exploration. The 2014 National Academies *Pathways*[3] report concluded that, "There is a consensus in national space policy, international coordination groups, and the public imagination for Mars as a major goal for human space exploration. NASA can sustain a human space exploration program that pursues the horizon goal of a surface landing on Mars with meaningful milestones and simultaneously reasserts U.S. leadership in space while allowing ample opportunity for substantial international collaboration—but only when that program has elements that are built in a logical sequence, and when it can fund a frequency of flights sufficiently high to ensure the maintenance of proficiency among ground personnel, mission controllers, and flight crews." The report also discussed the enduring questions and rationales for human spaceflight, public and stakeholder opinions, a strategic approach to a sustainable program of human spaceflight, and technical analysis and affordability.

NASA's Strategic Direction and the Need for a National Consensus[4], a 2012 report by the National Academies found that "NASA now faces major challenges in nearly all of its primary endeavors—human spaceflight, Earth and space science, and aeronautics. While the agency has undertaken new efforts to procure commercial transportation to resupply the International Space

[3] National Research Council. 2014. *Pathways to Exploration: Rationales and Approaches for a U.S. Program of Human Space Exploration*. Washington, DC: The National Academies Press. https://doi.org/10.17226/18801.
[4] National Research Council. 2012. *NASA's Strategic Direction and the Need for a National Consensus*. Washington, DC: The National Academies Press. https://doi.org/10.17226/18248.

Station (ISS) and has also initiated an effort to commercially procure crew transportation as well, the agency currently lacks a means of launching astronauts on a U.S. spacecraft to Earth orbit, where the agency operates the ISS, which was built at considerable time, effort, and expense.

Although gaps in U.S. human spaceflight capability have existed in the past, several other factors, in combination, make this a unique period for NASA. These include a lack of consensus on the next steps in the development of human spaceflight, increasing financial pressures, an aging infrastructure, and the emergence of additional space-capable nations—some friendly, some potentially unfriendly. In addition, U.S. leadership in space science is being threatened by insufficient budgets to carry out the missions identified in the strategic plans (decadal surveys) of the science communities, rising cost of missions, decreasing science budgets, and the collapse of partnerships with the European Space Agency (ESA)— this at a time when others (most notably ESA and China) are mounting increasingly ambitious space programs."

Science Priorities and National Academies Decadal Surveys

Space sciences benefit from centralized, long-term planning because individual facilities and missions require years of development, thousands of personnel, and hundreds of millions or even billions of taxpayer dollars. Since the 1960s, the astronomy community has convened a panel of experts every 10 years to set consensus priorities for the coming decade. These so-called decadal surveys are produced through a multi-year process facilitated by the National Academies of Sciences, Engineering, and Medicine and commissioned by federal agencies. Near the mid-point of each decade, the National Academies convenes expert panels to assess progress being made toward meeting the priority recommendations of the most recent decadal survey. Other disciplines have since followed the astronomy and astrophysics decadal survey process. At present, decadal surveys are carried out for Earth sciences from space, planetary science, solar and space physics, and life and physical sciences in space.

The Space Economy and Workforce

The Space Report issued annually by the Space Foundation[5] is a guide to global space activity and includes details and trends on the space economy, space infrastructure, space products and services, and the workforce. According to *The Space Report 2018*[6], 2017 continued the strong growth in the global space industry that began more than a decade ago. In 2017, global space activity[7] grew 7.4 percent to a total of about $384 billion. Eighty percent of the global space activity is now commercial[8], the biggest sectors of which are direct-to-home television (32%) and launch infrastructure and support systems (31%). World government space budgets grew 14 percent, with India, Italy, the United Kingdom, France, and Germany showing the strongest growth

[5] The Space Foundation, founded in Colorado Springs, CO is a nonprofit entity serving the global space community that is devoted to leading efforts in the awareness of space activities, educational programs, and major industry events.
[6] Background information available at: https://www.thespacereport.org/year/2018
[7] Global space activity includes world government *budgets* and commercial companies' *revenues*.
[8] "Commercial" revenues include the sale of products and services enabled by space assets and the products and services that enable private entities to access and use space.

among the major players[9]. The total U.S. government space budget for 2017 decreased 2.5 percent to $43.3 billion due to decreases in the defense space sector. The U.S. government space budget is split into approximately equal parts civil and defense-related.

In terms of the overall space workforce, while the U.S. private industry space companies employed over 128,000 professionals in 2016, that level was down 1.6 percent from 2015 to 2016 and 25.5 percent over the last decade. As the number of private jobs have decreased, however, wages have been growing in real terms. The average commercial space salary in 2016 was $117,000, more than twice the national average across all industries. NASA's workforce has remained steady from 2016 to 2018, but has declined 8.7 percent since 2000. NASA's workforce is also aged, with 15 percent under age 35 and 35 percent above age 54. Average NASA salaries are high overall, though in real terms they have declined 10 percent since 2011 to $107,000 in 2016, due in large part to a freeze on government salaries in 2011-2013 and only slight increases in 2014 and 2015. Despite the decline in wages, NASA has remained the "best place to work" among large federal agencies for the past six years.

International Cooperation/ Geopolitical Factors

International cooperation in space was a founding tenet of the National Aeronautics and Space Act (P.L. 85-568) that established NASA in 1958.[10] Further, the exploration and use of outer space for peaceful purposes is at the heart of the Outer Space Treaty of 1967 to which the United States is a signatory.[11] NASA has embraced international cooperation in its endeavors and the majority of its science missions involve some level of international contribution and partnership. According to NASA's 2014 publication, **Global Reach: A View of NASA's International Cooperation[12]**, NASA has carried out more than 3,000 agreements with over 120 nations and international organizations since its establishment in 1958. Today, NASA maintains hundreds of agreements with international partners. Through its partnerships with other nations, NASA benefits from a faster pace of scientific progress as a result of open access to science mission data and from sharing the costs and risks of space activities.

The 2009 National Academies report, America's Future in Civil Space, stated, "*Exerting a global leadership role in space activities is the best means to ensure that space activities can serve the broader security and economic interests of the nation.*"[13] The U.S.-led International Space Station, an international partnership consisting of the U.S., Russia, Japan, Canada and

[9] The Italian, British, French, and German budgets include both national space spending and their European Space Agency contributions.

[10] The 7th statement in the Act's declaration of policy and purpose states, "(7) *Cooperation by the United States with other nations and groups of nations in work done pursuant to this Act and in the peaceful application of the results, thereof*;"

[11] The Outer Space Treaty can be accessed at: https://www.state.gov/t/isn/5181.htm. The preamble to the Articles of the Treaty include: "*Desiring to contribute to broad international co-operation in the scientific as well as the legal aspects of the exploration and use of outer space for peaceful purposes,*

Believing that such co-operation will contribute to the development of mutual understanding and to the strengthening of friendly relations between States and peoples,"

[12] Available at https://www.nasa.gov/connect/ebooks/global_reach.html

[13] National Research Council, *America's Future in Space: Aligning the Civil Space Program with National Needs.* National Academies Press: Washington, D.C., 2009, p. 43.

members of the European Space Agency[14], is often cited as a shining example of American leadership. That partnership has been sustained through periodic geopolitical tensions among partner nations.

China. China is not among the International Space Station partners, though its progress in space activities is significant. China became the third nation to launch a human into space in 2003 and has carried out subsequent human missions, including its first space walk in 2008. In 2011, China launched a space station, Tiangong-1, into orbit. The Chinese lost control of the space station, and in 2018, it reentered Earth's atmosphere and crashed into the Pacific Ocean.[15] In the area of scientific exploration, in December 2018, China became the first nation to successfully land a rover, Chang'e-4, on the far side of the Moon.[16] Further, China has assembled the largest ground-based radio telescope, Five-hundred-meter Aperture Spherical Telescope (FAST), in the world.[17]

According to a report prepared for the **U.S.-China Economic and Security Review Commission, "China Dream, Space Dream: China's Progress in Space Technologies and Implications for the United States**,"[18] China seeks an influential and independent presence on the global front, and space is a means to support this overarching strategy. The report states, "Indeed, China's goal is to become a space power on par with the United States and to foster a space industry that is the equal of those in the United States, Europe, and Russia. China takes a comprehensive, long-term approach to this goal that emphasizes the accrual of the military, economic, and political benefits space can provide."

The Space Environment

Orbital Debris. One of the most significant factors affecting the environment of space and the current and future activities carried out in space is orbital debris, which includes debris fragments, used rocket bodies, and other man-made objects. Orbital debris is hazardous; it can travel through space at up to 17,500 mph such that even a small piece of debris that collides with the International Space Station could be catastrophic.[19] According to NASA, millimeter-sized orbital debris, which are too small to be tracked by U.S. government capabilities, pose the biggest risk to spacecraft operating in low Earth orbit. The Department of Defense's Space Surveillance Network (SSN)

[14] European Space Agency members: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland and the United Kingdom. Slovenia is an Associate Member. Canada takes part in some projects under a cooperation agreement.

[15] Kenneth Chang, "Tiangong-1, China's First Space Station, Crashes Into the Pacific", *New York Times*, April 1, 2018.

[16] Steven Lee Myers, "China's Moon Landing: Lunar Rover Begins its Exploration" *New York Times*, January 3, 2019.

[17] Chris Buckley and Adam Wu, "China Hunts for Scientific Glory, and Aliens, With New Telescope", New York Times, September 26, 2016.

[18] Kevin Pollpeter, Eric Anderson, Jordan Wilson, and Fan Yang, University of California's Institute on Global Conflict and Cooperation, "China Dream, Space Dream: China's Progress in Space Technologies and Implications for the United States" prepared for the U.S.-China Economic and Security Review Commission, 2015. Available at: https://www.uscc.gov/Research/china-dream-space-dream-chinas-progress-space-technologies-and-implications-united-states

[19] National Aeronautics and Space Administration, "Space Debris and Human Spacecraft", September 26, 2013. Accessed at: https://www.nasa.gov/mission_pages/station/news/orbital_debris.html

currently tracks approximately 23,000 objects of about 10 cm or larger in space including active satellites and spacecraft, debris fragments, used rocket bodies, and other debris[20]. Events such as China's anti-satellite test in 2007 created more than 3000 pieces of debris.[21]

NASA was the first agency to develop orbital debris mitigation guidelines. Those guidelines were instrumental in the development of U.S. Government Orbital Debris Mitigation Standard Practices. Other nations have followed suit with their own debris mitigation guidelines, and nations have worked together on consensus guidelines. In 2007, the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) adopted a consensus set of space debris mitigation guidelines, which were endorsed by the United Nations in 2008.

[20] Frequently Asked Questions at space-track.org, accessed at https://www.space-track.org/documentation#/faq
[21] National Aeronautics and Space Administration, "Space Debris and Human Spacecraft", September 26, 2013. Accessed at: https://www.nasa.gov/mission_pages/station/news/orbital_debris.html