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## **Congressional Committee Resources on Space Policy During the 115th Congress (2017-2018): Providing Context and Insight Into U.S. Government Space Policy**

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# Congressional Committee Resources on Space Policy During the 115th Congress (2017–2018): Providing Context and Insight Into US Government Space Policy

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## ABSTRACT

Article 1 of the US Constitution assigns the US Congress numerous responsibilities. These include creating new laws, revising existing laws, funding government programs, and conducting oversight of these programs' performance. Oversight of US Government agency space policy programs is executed by various congressional space policy committees including the House and Senate Science Committees, Armed Services, and Appropriations Committees. These committees conduct many public hearings on space policy, which invite expert witnesses to testify on US space policy programs and feature debate on the strengths and weaknesses of these programs. Documentation produced by these committees is widely available to the public, except for sensitive national security space policy matters. This assessment examines congressional committee oversight of US space policy programs during the 115th Congress (2017–2018) and reflects the variety of developments in space policy receiving congressional scrutiny.

## 1. Introduction

An important entity influencing US Government space policy is the US Congress and congressional committees. Article 1 and Sections 7–8 of the US Constitution assign Congress numerous critically important policymaking responsibilities. These include raising revenue for government program spending, borrowing money on US credit, promoting the progress of science and the useful arts, raising and supporting armies, regulating trade with foreign countries, and providing for and maintaining a navy [1].

Congress is responsible for approving new legislation, revising existing legislation, funding government programs, and conducting oversight on government performance. Consequently, congressional committee hearings and reports are extremely valuable for gaining enhanced understanding of the US space policy. As part of annual authorization legislation or other congressional oversight requirements, these committees may require agencies to prepare a prodigious amount of reports to assist Congress in its oversight activities. One description of the value of congressional information resources contends as follows:

Committees are the instruments through which Congress chooses to screen and process proposals to change public policy. A committee decision to hold hearings, except for the annual appropriations and budget process, indicates that a matter has crossed the threshold of political salience. These proceedings serve to focus public and political attention and may be a prelude or an alternative to legislation [2].

Representatives and senators choose to be on space policy committees for numerous reasons. These include genuine interest in civil and military space policy topics, the presence of civil and military space agencies or contractors in their state or district, the desire to prove their loyalty to their party's position on space policy and other issues, their record of demonstrating that they can engage in successful fundraising for party election campaigns and candidates, their willingness to defer to party colleagues including committee chairs with more experience in space policy issues than they possess, and recognizing that their committee oversight can influence employee morale at civilian and military space policy agencies. Rules of House and Senate Democratic and Republican Party Conferences and seniority also influence committee appointments. Committee professional staff of both parties provide significant policy expertise to committee work and are heavily involved in inviting and influencing the testimony of expert witnesses during committee hearings [3].

This work examines congressional committee hearings and debates on US space policy topics during the 115th Congress (2017–2018) as a way of examining the interaction between Congress and civilian and military participants in US government and private sector space policy arenas. This will primarily encompass House and Senate science committees that have space policy subcommittees, armed service committees that will scrutinize military space policy matters, and appropriations committees subcommittees on defense and science that authorize funding for civil, commercial, and military space programs. Committees conduct legislative hearings to consider pending or revising exist-

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ing legislation and extend, eliminate, or reduce annual funding authorizing these programs' oversight hearings to examine agency program performance, investigative hearings to scrutinize possible criminal conduct, fraud, or other wrongdoing in agency program performance, and Senate committees conduct hearings to consider presidential nominations for offices such as NASA Administrator. During this congressional session, the House Appropriations Committee held 7 space policy hearings, the House Armed Services Committee held 12 space policy hearings, the House Science, Space, and Technology Committee held 19 hearings, the Senate Appropriations Committee held 24 hearings, the Senate Armed Services Committee held 6 hearings, and the Senate Commerce, Science, and Transportation Committee held 12 hearings [4].

These documents include testimony from expert witnesses from US government agencies, the US military, academic experts, space scientists, economic experts from the commercial space industry, foreign nationals, and even average citizens. Witnesses are invited to testify before these committees, committee members, and their professional staff to achieve a relative balance of viewpoints on issues discussed, although parties controlling an individual congressional chamber, as is occurring during the 116th Congress (2019–2020), will invite more witnesses supporting their perspectives. Witnesses can also be advised by committee staff on the content of their testimony. Witnesses provide sworn testimony to committees as if they were testifying in a legal court and are subject up to five years in prison and fines under Title 18 of the United States Code for providing fake, fictitious, or fraudulent statements each time such an offense occurs [5].

### 1.1. Committee activity reports

An important barometer of congressional committee oversight of US space policy programs can be found in congressional session committee activity reports issued at the end of two-year congressional sessions by relevant space policy committees. These reports detail committee and subcommittee jurisdictional areas, oversight plans, committee members, professional staff members, legislation considered, hearings conducted, committee rules, and reports filed on proposed legislation. House Armed Services Committee membership was 60 during the 115th Congress, and its Subcommittee on Strategic Forces, which includes military space programs and national intelligence space programs within its jurisdictional coverage, had 20 members. The Committee also described its oversight activities encompassing national security space [6].

The House Science, Space, and Technology Committee had 39 members during this congressional session, and its Space Subcommittee had 23 members. This subcommittee's jurisdiction includes aeronautical and aeronautical research and development; national space policy; access to space; the NASA and its contractor and government-owned laboratories; space commercialization, including Commerce and Transportation Department commercial space activities; the National Space Council; space communications; earth remote sensing policy; and space law. Subcommittee areas of oversight emphasis during this Congress included NASA human spaceflight, Federal Aviation Administration commercial space transportation, NASA space science, commercial orbital transportation services, International Space Station (ISS) use and operation, NASA contract and financial management, near-Earth objects, and space traffic management [7].

The Senate Armed Services Committee had 27 members during the 115th Congress, and its Subcommittee on Strategic forces, whose jurisdiction includes ballistic missile defense, military space programs, and national intelligence, had 11 members. This committee's constitutional responsibilities also include approving military promotions and presidential nominations to important civilian and military national security policymaking positions [8].

The Senate Commerce, Science, and Transportation Committee had 27 members during the 115th Congress, and its Space, Science,

and Competitiveness Subcommittee had 13 members. Nonmilitary aeronautical and space sciences are jurisdictional responsibilities of this committee including confirming key presidential appointees such as the current NASA Administrator James Bridenstine, whose controversial confirmation process will be covered later [9].

### 1.2. Committee markups

Committee markups of legislation are another way in which Congress demonstrates its oversight responsibilities. During these events, jurisdictional committees in each chamber go through proposed legislation line-by-line to approve, amend, or reject its contents. House and Senate majority parties, committees, subcommittees, and their professional staff determine the small percentage of legislation referred to them deserving of receiving further scrutiny. One or more days of public hearings may be conducted to receive testimony on issues covered by this legislation with these meetings called markups. Committee and subcommittee members mark up legislation as they decide what amendments to propose to the House or Senate. The committee will eventually order the bill reported to the House or Senate floor for consideration by either chamber.

Selecting the legislation's text, which involves the committee's staff working with help from attorneys in the House Office of Law Revision Counsel, reflects the committee chair's policy preferences. When a markup session begins, the committee's clerk reads the entire text of the proposed legislation, although this can be waived by unanimous consent of committee or subcommittee members who are familiar with the legislation's text. Committee members have the chance to speak on the legislation and offer amendments. For legislation to pass, this markup must occur in both chambers and have identical wording before it can be considered by the full House or Senate [10].

During the 115th Congress, the House Science Space and Technology Committee held two notable markups on space policy matters. On September 28, 2017, they marked up H.R. 1159 the U.S.-Israel Space Cooperation Act, which sought to promote continued cooperation between the NASA and the Israel Space Agency on peaceful space exploration and science in areas of mutual interest. Speaking in support of this markup, Rep. Eddie Bernice Johnson (D-TX) stressed this would be an appropriate way for the NASA to remember astronauts killed in the Shuttle Columbia accident on February 1, 2003, including the Israeli astronaut Ilan Ramon [11].

On April 17, 2018, this committee marked up H.R. 5503 the National Aeronautics and Space Administration Authorization of Act of 2018 and H.R. 5509 Innovations in Mentoring, Training, and Apprenticeships Act. An amendment to this legislation that was successfully offered by Rep. Brian Babin (R-TX) inserted \$350 million for a second mobile launch platform and associated Space Launch System activities. A successful amendment to this H.R. 5509 was offered by Rep. Suzanne Bonamici (D-OR) who inserted the language "to offer apprenticeships" to p. 4 line 18 of this legislation requiring industry or sector partnerships to offer apprenticeships [12].

January 24, 2017, saw the Senate Commerce, Science, and Transportation Committee markup various pieces of legislation. One of these was S. 141 the Space Weather Research and Forecasting Act. Sponsored by senators Cory Booker (D-NJ), Cory Gardner (R-CO), Gary Peters (D-MI), and Roger Wicker (R-MS), this legislation sought to increase terrestrial observation cooperation between the NASA and the National Oceanic and Atmospheric Administration (NOAA) in developing space weather instruments, spacecraft, and technologies while making US policy to establish and sustain baseline capability for space weather operations and improving interagency cooperation in space weather policy [13].

June 27, 2018 saw this committee markup H.R. 4254 Women in Aerospace Education Act, sponsored by a bipartisan group of House members. This legislation's intention was directing the NASA to institute a process to prioritize the recruitment of qualified women or his-

torically underrepresented members in science, technology, engineering, and mathematics and computer science for NASA fellowships and internships with relevance to the aerospace sector and related fields [14].

### 1.3. Selected house committee hearings

The House Appropriations Committee is an important congressional participant in overseeing and funding congressional space programs and telling agencies how much money they may spend. This influence is derived from Article I Section 9 of the US Constitution: “No money shall be drawn from the treasury, but in consequence of appropriations made by law, and a regular statement and account of receipts and expenditures of all public money shall be published from time to time.” This committee's subcommittees on Commerce, Justice, Science, and Related Agencies and Defense are responsible for civilian and military space policymaking. The Commerce, Justice, Science, and Related Agencies Subcommittee had 11 members during the 115th Congress, while the Subcommittee on Defense had 16 members during the 115th Congress. The Appropriations Committee jurisdiction includes the following:

- Appropriating revenue for governmental support.
- Rescinding appropriations contained in Appropriations Acts.
- Transferring unexpected balances.
- Dealing with bill and joint resolutions reported by other committees providing new entitlement authority defined in Section 3 (9) of the 1974 Congressional Budget Act and referred to the committee under clause 4(a)(2) of this statute [15].

A February 28, 2017, Science Subcommittee hearing saw Rep. Bill Posey (R-FL) asked for continued government support of federal space programs including the Space Launch System (SLS), Orion spacecraft, and exploration ground systems while emphasizing ongoing Chinese and Russian space capability developments and warning that surrendering US space dominance is unacceptable on national security and military readiness grounds. He went on to note that the SLS involves thousands of skilled workers in nearly every state building the necessary hardware and technology to take the U.S. to the Moon and Mars while also stressing the need to upgrade 1960's infrastructure at the Kennedy Space Center [16].

The Defense Subcommittee's March 9, 2017, hearing saw Rep. Jim Bridenstine (R-OK) request that \$10 million be appropriated for the Air Force's weather service research, development, testing, and evaluation funds and that at least \$50 million be appropriated for the Air Force's satellite communications pilot program. Rep. Paul Cook (R-CA) urged spending an additional \$4 million in GPS software for the Army Geospatial Center to get up-to-date information to land forces to make informed tactical decisions. Rep. Ted Lieu (D-CA) contended his congressional district was a critical hub for aerospace design, engineering, and manufacturing hosting companies and universities such as the Aerospace Corporation focusing on space and aerospace. Finally, Rep. Vicki Harzler (R-MO) stressed that the military must have overall financial support to meet emerging national security challenge in areas such as national security space defense and ballistic missile defense to meet emerging challenges from China, Iran, North Korea, and Russia [17].

A May 25, 2017, Science Subcommittee hearing on NASA's budget request saw Acting Administrator Robert Lightfoot present the Trump Administration's \$19.1 billion Fiscal Year 2018 budget request, which was \$561 million less than this agency's prior year budget request. Subcommittee Chair Rep. John Culberson (R-TX) noted that prior year NASA spending included \$184 million to repair damage at NASA facilities at Louisiana's Michoud Assembly Facility and Florida's Kennedy Space Center owing to hurricane and tornado damage while urging the NASA to use commercial space industry suppliers to take spacecraft to low Earth orbit, so the agency can focus on deep-space orbit. Subcom-

mittee ranking member Rep. Jose Serrano (D-NY) expressed concern about proposed defunding of NASA's Office of Education activities, \$166.9 million in funding cuts to agency's earth science activities, and voiced the desire to learn more about the NASA's long-term plans for human space exploration in areas such as advanced communications; astronaut health protection; and entry, descent, and landing capabilities [18].

House Armed Services Committee space policy committee hearings included a March 29, 2017, hearing on threats to space assets and their relevance to homeland security and a March 14, 2018, hearing on space warfighting readiness. Former US Air Force Space Command Commander General William Shelton told committee members that most Americans are not aware how dependent the U.S. is on satellites for civilian and military purposes, noting that a Space Foundation report stressed the global space industry is worth \$325 billion; that space services are similar to a utility, maintaining that potential US adversaries are aware of our dependence on satellites; that post-1991 U.S. combat operations give hostile countries the opportunity to learn about US capabilities; and that these nations are actively testing methods to deny the US access to space during war including developing signal jamming capabilities and destroying satellites by kill vehicles as China successfully demonstrated in 2007. Such counterspace weapons systems can deny use of critical navigation, timing, and long-distance communication services adversely affecting critical warning and strategic capabilities. This hearing also discussed the possible establishment of a space corps or space force with former Deputy Assistant Secretary of Defense for Space Policy Doug Loverro, maintaining that the 2000 Air Force space operators need an identifiable existence with the Air Force and that 3000 space acquisition personnel in the National Reconnaissance Office and Space and Missile Systems Center should also be considered as part of this force [19].

Former US Strategic Command (STRATCOM) leader General C. Robert Kehler commented that the U.S. is losing its competitive advantages as the world's leading spacefaring nation. He noted that adversaries have aggressively developed forces that can challenge US space capabilities from the ground, cyberspace, and in space, maintaining “Adversaries will be deterred if they believe they cannot achieve their objectives, will suffer unacceptable consequences if they try, or both.” Kehler went on to assert that the U.S. must be prepared to plan and conduct complex space operations involving joint interagency and combined allied capabilities in forces within a context of expanded commercial, non-governmental, and international actors and interests. He concluded by stressing space's criticality to the US warfighting structure, and challenges to national space capabilities must be addressed within this structural context [20].

The House Science, Space and Technology Committee addressed multiple space policy topics during its 115th Congress legislative oversight activities. A March 8, 2017, hearing by this committee's Space Subcommittee reviewed emerging US international space policy obligations resulting from new and innovative space activities. Subcommittee Chair Rep. Brian Babin (R-TX) noted that Article VI of the 1967 Outer Space Treaty (OST) allowed the U.S. to authorize and supervise private sector space activities. He noted that in the subsequent five decades, US companies had developed and invested in technology and spacecraft for varied activities including satellite servicing, manufacturing, human habitation, and space resource utilization [21].

Science Committee Chair Rep. Lamar Smith (R-TX) expressed concern over the Obama Administration's 2016 issuance of a report calling for expansive space traffic regulations. He urged the committee to focus on minimizing and avoiding federal agency space traffic regulation and empowering private investments and discoveries. Attorney Laura Montgomery of Ground Based Space Matters, LLC urged the U.S. not to regulate new commercial space activities including lunar habitats or mining, or satellite servicing, while noting that Article VI says space activities of nongovernmental entities require authorization and supervision by authorizing national governments. She went on to note that Arti-

cle VI is not self-executing and that it cannot be enforced as a federal law unless Congress enacts legislation to implement Article VI. Eli Dourado, the Director of George Mason University's Mercatus Center's Technology Policy Program, urged Congress to consider blanket authorization for all nongovernmental space operations by not injuring other parties in their peaceful exploration and use of outer space.

Former Deputy Assistant Secretary of Defense for Space Policy Doug Loverro asserted that US military strength in space is based on the strength of the US commercial space industry and warned that lapses in spaceflight safety would seriously damage the commercial spaceflight industry. University of Nebraska-Lincoln's adjunct law professor Dennis Burnett maintained that emerging space entrepreneurs require freedom to innovate new technologies, products, and business methods while deserving freedom from arbitrary restraints and a process capable of providing authorization at the speed of business. Congressional Research Service American National Government Specialist Henry Hogue discussed four regulatory models involving quasi-governmental or nongovernmental organizations, including which might be used for the commercial space industry:

- A. Government corporations: Intended to perform a public purpose and give corporate form with private sector-like flexibilities.
- B. Nongovernmental standard setting: Private and voluntary organizations developing technical specifications for various reasons to ensure product compatibility from different manufacturers.
- C. Establishing a federally chartered corporation with congressionally sanctioned exclusive jurisdiction over activity in a specific area of national life, e.g., US Olympic Committee.
- D. Self-regulatory organizations: Private entities formed by industry members to self-regulate to deter governmental regulation by providing the industry can supervise itself or because government regulation is impractical [22].

Two weeks later, this committee held a hearing on the status of the ISS after 2024. A March 22, 2017, hearing focused on the ISS's future since 2015 congressional legislation extended ISS operations until 2024. Witnesses testifying included NASA Associate Administrator for Human Explorations and Operations William Gerstenmaier; Coalition for Deep Space Exploration Executive Director Mary Lynn Dittmar; Commercial Spaceflight Federation President Eric Stallmer; and University of Florida Professor Robert Ferl. These witnesses were questioned by committee members on various topics. Gerstenmaier noted that the ISS was the most complex engineering structure ever constructed, consisting of 37 space shuttle flights; 197 h of US and Russian space walks encompassing 1000 h; 12 years of construction; a price of \$67 billion including shuttle launch costs; and a mass of 925,000 pounds [23].

Ferl maintained:

The ISS is currently the only space-based platform that provides extended access to the spaceflight environment and, as such, provides the only means to assess the long-term effects of this environment on terrestrial organisms and the physical systems that would be used to support them. Such data are crucial to inform—more fully—the deep space exploration ideas such as missions to Mars [24].

During questioning, Rep. Clay Higgins (R-LA) asked Gerstenmaier, “Do you envision beyond 2024 the existing ISS to be in any way useful for that manned space exploration or does it have a role, so you envision that role, and if so, please explain, and if not please expound.” Gerstenmaier's response was as follows:

Mr. Gerstenmaier: I believe the station has a critical role in exploration as we have technical challenges that we have to conquer or overcome as we go beyond low-Earth orbit. The requirements to keep technology highly reliable with low resources to essentially break the tie back to the planet Earth—Space Sta-

tion is resupplied all the time today by cargo vehicles to and from the Earth, but as we move human presence deeper into the solar system, we need to break that tie back with Earth, and the Space Station is a great testbed to test that technology, to understand the next generation of life support systems .... We need to use the unique properties of Space Station to actually test that next generation of life support systems. Understanding how the human performs in space is important, and understanding even how we break that tie and we keep sensors like oxygen measurement devices calibrated for years without returning to the ground for recalibration. So I think this station plays a pretty critical role. I don't think we'll have all those technology challenges done. We're going to need some facility in space beyond 2024 to keep working as we break the tie of the planet and move human presence further into the solar system [25].

Rep. Daniel Lipinski (D-IL) asked Stallmar and Dittmer, “Can you speak to the readiness of the private sector to fly its own modules in low-Earth orbit without NASA assistance or physical attachment to the ISS? And then can you talk about what roles that NASA and ISS played thus far and what role can it should it play in the future for this?” Stallmer emphasized he saw a tremendous partnership between the NASA and the private sector in commercial space transportation while also stressing what he saw as the critical importance of the private sector's partnership with the NASA on technology transfer and the investment the NASA is making in such transfer. Dittmar stated that the partnership with the NASA gives the commercial space sector the opportunity to develop capabilities and hand over knowledge built up over multiple years which is essential to commercial success [26].

Rep. Jim Banks (R-IN) asked witnesses how a Chinese space station might compete with commercial space platforms. Gerstenmaier mentioned he envisioned other countries could interact with China if the US and European countries did not have a space station available and that would transfer US scientific and technological leadership to China. Stallmer added that a Chinese space station would incentivize the U.S. to work harder as a nation as a space industry to achieve its commercial space objectives [27].

This committee held a December 6, 2017, hearing examining NASA program development of four telescopes: the Transiting Exoplanet Survey Satellite (TESS), the James Webb Space Telescope (JWST), the Wide Field Infrared Survey Telescope (WFIRST), and planning for a next-generation space telescope. Witnesses testifying at this hearing included NASA Science Mission Directorate Associate Director Thomas Zurbuchen, Christina Chaplain from the Government Accountability Office, former Goddard Space Flight Center Director and Martin Marietta Corporation President A. Thomas Young, Association of Universities for Research in Astronomy President Matt Mountain, and National Academies of Science, Engineering, and Medicine representative Chris McKee.

Babin noted that the WFIRST has 100 times the capability of the Hubble Space Telescope while also stressing that a recent independent review committee has mentioned concerns with the WFIRST's costs. Subcommittee Ranking Member Amir Bera (D-CA) noted that the Compton Gamma Ray Observatory created the first all-sky map of gamma radiation while also mentioning March 2018 would see the TESS launched to conduct the first all-sky survey transiting exoplanets from space [28].

Smith noted that the JWST is a couple years away from launch and that in January 2016, the NASA initiated four Decadal Survey Mission Concept Studies for a space telescope slated for launch in the 2030s. He also observed that the forthcoming heavy-lift capability of the SLS could produce telescopes larger than the JWST capable of scanning exoplanets for signatures, indicating the presence of continents, oceans, habitable conditions, and potentially life. Zurbuchen noted that the TESS was selected as an astrophysics explorer in 2013, is undergoing integration and testing, and was scheduled to achieve launch readi-

ness capability in March 2018, with launch to have occurred on April 18, 2018 [29].

He also noted that the JWST was scheduled for launch in 2019, with this telescope being the most powerful space telescope ever and kept cold by a tennis court-sized sun shade to detect infrared light from very faint and distant objects. Zurbuchen also noted JWST's sunshield and spacecraft bus experienced delays during Northrop Grumman's testing and integration delaying its targeted launch from October 2018 to March–June 2019. He went on to note that the WFIRST would carry a technology demonstration coronagraph instrument to provide detailed exoplanet analysis [30].

Testifying on fiscal and managerial aspects of these three telescopes, Chaplain maintained they represented investment of at least \$12.4 billion or nearly 50% of NASA's astrophysics budget. The TESS is the smallest project at \$336 million and had not incurred cost or schedule delays, despite facing technical challenges such as camera performance. She mentioned the JWST is expected to cost \$8.8 billion, which is 78% higher than its anticipated baseline cost. After 2011 rebaselining, the JWST has stayed within cost and schedule despite experiencing multiple engineering, manufacturing, and technical problems. Chaplain concluded by noting that the WFIRST is early in its development process, with preliminary cost estimates ranging from \$3.2 to 3.8 billion and a preliminary launch date range of 2024–2026. She also noted the NASA has made significant improvements in cost and schedule estimation and oversight processes [31].

Young emphasized that JWST mission success should be its most important goal and that everything should be done to achieve this objective. He went on to assert that additional WFIRST requirements enhance the mission's scientific value with added financial cost, which he described as “continual requirements creep.” Young also stressed his belief that the NASA was capable of managing large space telescope projects [32]. Mountain emphasized that it is technologically possible to potentially detect characteristics of life on a planet rotating around another star, that emerging NASA SLS telescope capabilities make possible detection of signs of life on an exoplanet nearly 200 trillion miles away, and that the NASA is considering the possible use of a large 15-m-diameter optical infrared telescope Large Ultraviolet Optical Infrared Surveyor with a potential launch capability in the 2030s [33].

McKee, representing the National Academies Committee on Astronomy and Astrophysics, stressed the role played by the National Academies advice on decadal space science recommendations. He referenced this organization's 2016 report *New Worlds, New Horizons: A Midterm Assessment*, which held that scientists working with cutting-edge instruments and new data collection and analysis capabilities had made significant space science discoveries. He also stressed the potential value of the Laser Interferometer Space Antenna collaboration between the NASA and the European Space Agency, which will observe gravitational waves and measure ripples in space-time produced by the merger of black holes much larger than that detectable with existing technology. The year 2034 is the projected launch date for this endeavor [34].

An April 26, 2018, hearing by two subcommittee of this committee, cochaired by Andy Biggs (R-AZ) and Babin, examined space weather developments from the perspectives of affected stakeholders. Witnesses included NOAA Assistant Secretary of Commerce for Environmental Observation and Prediction Neil Jacobs, NASA Chief Scientist of the Science Mission Directorate's Heliophysics Division Jim Spann, National Academy of Science Senior Scientist from the High Altitude Observatory Sarah Gibson, and Space Environment Technologies President and Chief Scientist W. Kent Tobiska. Biggs noted the presence of significant space weather developments including innovative space weather technologies, the accuracy of space weather forecasting models, and possible impacts space weather can have on terrestrial environments. He also noted that the sun influences space and earth weather in the form of solar winds, which can interact with the Earth's magnetic field and create weather storms capable of causing problems with the perfor-

mance and reliability space-borne and ground-based technologies, potentially endangering human life or health [35].

Jacobs stressed NOAA's serving as the US official civilian space weather, forecasting, warning, and alerting source to the public, industry, and government agencies. Its Space Weather Prediction Center (SWPC) operates 24/7 providing real-time forecasting and warnings of solar geophysical events. The SWPC also works with the Air Force on national security needs and space weather information while collaborating with the NASA, the National Science Foundation, US Geological Survey, commercial service providers, private industry, and academia. The NOAA relies on two primary observational assets for its forecasts and warning, using one satellite for sun coronal imagery and another satellite for earthbound solar wind. He went on to add that in 2017, the NOAA began working with the Naval Research Laboratory on developing a flight compact coronagraph to obtain imagery, and NOAA's Deep Space Climate Observatory satellite, orbiting a million miles from Earth, is critical for real-time measurements of earthbound solar winds. Jacobs also stressed that the NOAA works with the private sector to assist US airlines, electric power companies, and satellite companies [36].

Spann emphasized NASA's work with other federal agencies to better understand space weather. He noted the electric power industry's susceptibility to geomagnetically induced currents that can overload unprotected power grids without warning and produce widespread power outages. Geomagnetic and radiation storms can affect the space industry by disrupting satellite communication and television service, while space weather irregularities can adversely impact warfighters, first responders, truckers, oil drillers, large-scale farmers, and the aviation industry. He also noted the forthcoming Parker Solar Probe (launched on August 12, 2018) launch that would dive into the sun's corona and explore scientific foundations of the solar wind in hope of improving forecasts of major solar eruptions which may affect near-Earth space weather [37].

Gibson emphasized that space weather can have extremely adverse consequences on Earth referring to the 1859 Carrington solar flare and magnetic storm producing auroras as far south as Cuba and igniting telegraph line fires. Contending that a contemporary superstorm of this size could cost tens of billions of dollars per day, Gibson asserted that such damage could potentially reach trillions if extended power outages and global supply chain disruptions occur. She also added that analysis of power grid disruption-associated insurance claims produced estimated costs of \$10 billion in the U.S. for nonextreme events and even moderate space weather increases risk for serious hazards [38].

Tobiska noted space weather occurs with energy transfer from the Sun to Earth producing sudden changes in ground current, atmospheric radiation, ionosphere, and upper atmospheric densities. This was reflected in a 1989 geomagnetic storm causing the Hydro-Quebec power collapse, leaving nine million customers without power. He also noted that pilots, flight attendants, and frequent flyers can receive excessive radiation doses. Galactic cosmic rays are the main causes of such doses, although solar flares can triple solar ray dosage. Another point of his testimony stressed that the fourth largest flare in history occurred nine days after Hurricane Katrina caused blackouts, affecting high-frequency radio communications, wiping out the communication infrastructure, and making it temporarily impossible for Coast Guard recovery ships to communicate with rescue helicopters [39].

A final illustration of the severity of space weather came when Dana Rohrabacher (R-CA) asked witnesses how the impact of a space weather storm can be compared with that of an electromagnetic pulse (EMP) attack. Tobiska said the Nuclear Regulatory Commission studied that and stressed his belief that an EMP attack would be comparable to the Carrington event and produce days, weeks, or months of power outages. He also stressed the absence of backup transformers to replace existing transformers that may be decapitated by EMP. Spann commented that any use of electrical outlets would also be adversely im-

ected by an EMP incident along with access to services using GPS including cell phones and credit cards [40].

Concern over costs overruns and management problems with the JWST were examined by the Space Subcommittee during July 25–26, 2018, hearings featuring testimony from NASA Administrator James Bridenstine, JWST Independent Review Board (IRB) Chair Tom Young, and Northrop Grumman CEO Wesley Bush. In his opening statement, Smith inserted a chart inserted into the hearing transcript noting that the JWST costs had increased from \$500 million in 2006 to \$8.8 billion in 2018 and were projected to reach \$9.66 billion by 2021. The JWST's original launch date of 2007 has been pushed back to 2021, and the NASA has been notifying the committee about cost breaches since March 26, 2018. Smith also stressed his concern that when contractors make mistakes, no one is held accountable, while warning that taxpayer money is being wasted and that contractors must deliver projects on time and on budget if space exploration is to continue receiving public support [41].

Committee ranking member Eddie Bernice Johnson (D-TX) said the JWST's IRB clearly chided the NASA and prime contractor Northrop Grumman for contributing to the project's 29-month delay and \$1 billion cost increase. She also noted the report finding complex and confusing management project reporting along with inconsistent and uncoordinated JWST communications within the NASA and external stakeholders, including Congress. Babin noted that the \$803 million required to fund the JWST cost breach could “fund nearly every one of NASA's science funding shortfalls from fiscal year 2013 all the way up through fiscal year 2016. These projects include earth science and education projects greatly promoted by our Democratic colleagues on the committee.” Bera noted the IRB stressed that the JWST should continue, despite its cost overruns and schedule delays, based on its scientific potential and the need to maintain US astrophysics and astronomy leadership [42].

NASA Administrator James Bridenstine testified that the optical telescope element and spacecraft have been the primary problems with the JWST. He noted the spacecraft sunshield needed to be capable of withstanding solar temperatures of 7° Kelvin or near-absolute zero to use the telescope's infrared side to detect galaxy heat signatures originating with the beginning of time. In addition, he stated a heat shield with five layers was needed to be capable of absorbing temperatures from 300° Fahrenheit to –390° Fahrenheit. The administrator also noted that IRB testing found additional human errors within the program contributing to further delays and cost increase [43].

IRB Chair Young noted that the IRB made 32 recommendations for the JWST and that implementing all of these is necessary to maximize program success. He credits the JWST program with respect to delivering all flight hardware, integrating science instruments into the science module that has met its requirements, and delivering them to Northrop Grumman. Concerns remain with project integration and test, with human errors producing significant delays. Examples of these errors include the following:

- A wrong solvent being used to clean propulsion valves;
- Test wiring erroneously connected to flight hardware with inadequate inspection; and
- Improperly installing sunshield fastener covers [44].

Young noted that spacecraft and sunshield deployments occurring during observatory commissioning remain to be of high risk. Nearly 307 single-point failure items must work for successful deployments, which is comparable with the entry-descent-landing phase of a Mars science laboratory mission that experienced 72 single-point failures when it landed on Mars in 2012. He also cited human errors, embedded problems, insufficient experience in areas such as the sunshield, excessive optimism, and systematic complexity as key factors causing program delay and cost increases [45].

In his testimony representing Northrop Grumman, Bush noted that the JWST has a 21-foot primary mirror and a sunshield as large as a tennis court (40 × 70 feet) that has to be designed to fold up similar to an origami piece with 18 hexagonal mirrors and fit into a launch vehicle. After launch, the JWST will slowly unpack itself in space until it reaches its operating location 1,000,000 miles from Earth, where there will be a temperature swing of nearly 600° between the optical mirror and the other side of the sunshield. He went on to note that building a telescope capable of operating in a harsh environment beyond satellite servicing reach requires extensive on-ground testing to ensure it operates in space. He acknowledged the seriousness of Northrop Grumman's responsibilities and admitted its contribution to program delays while also maintaining that lessons learned will reduce future error possibility [46].

#### 1.4. Selected senate committee hearings

Senate committee hearings on space policy are conducted by the Senate Appropriations, Armed Services, and Commerce, Science, and Transportation Committees, with the second committee overseeing military space policy matters and the third committee overseeing NASA and civilian space policy matters. Senate committees are of extra importance because the US Senate is responsible for confirming or rejecting presidential nominees to positions such as NASA Administrator under Article 1 Section 2 of the US Constitution and approving treaties, with foreign countries or international government organizations on space policy-related matters [47].

The Senate Appropriations Committee has a similar jurisdictional scope to its House counterpart. Its Commerce, Justice, Science, and Related Agencies and Defense Subcommittees are responsible for civilian governmental, commercial space policy, and military space policy funding. During the 115th Congress, the Commerce, Science, Justice, and Related Agencies Subcommittee had 17 members, and the Defense Subcommittee had 19 members [48]. During an April 4, 2017, hearing, the witness Dr. Antonio J. Busalacchi, Jr., the President of the University Consortium for Atmospheric Research, noted that congressional support enabled NASA's 2015 launch of the Soil Moisture Active Passive satellite to measure land surface soil moisture and freeze-thaw state on a nearly global scale, that the NASA and the NOAA were able to launch the Geostationary Operational Environmental Satellite (GOES) 16 series in 2016 to provide weather pattern images every 30 s, providing more timely and accurate space-based information on severe storms. Busalacchi also noted that GOES-16's Geostationary Light Mapper can detect the presence of lightning, providing forecasters the ability to focus on developing extreme weather events producing precipitation [49].

Secretary of the Air Force Heather Wilson testified before the Defense Subcommittee on June 21, 2017. She noted that the Trump Administration's FY 2018 space budget request was increasing from \$6.5 billion in FY 2017 to \$7.8 billion in Fiscal Year FY 2018, representing a 27% increase in research, development, testing, and evaluation and a 12% space procurement increase. Specific components requested include Space-Based Infrared Systems 5 and 6 satellites, purchasing terminals, ground control systems, satellite communications survey, and funding three launches as part of the Evolved Expendable Launch Vehicle program. Wilson also stressed the need to improve antijamming efforts against GPS satellites and maintain secure military access to GPS. She concluded by stressing that the Air Force budget funds the Space Security and Defense Program and National Space Defense Center, which works with concepts intended to enhance space freedom of action and resilience in collaboration with the intelligence community while also supporting space force training [50].

Commerce Secretary Wilbur Ross testified before the Appropriations Committee's Science Subcommittee on May 10, 2018. He noted that the Trump Administration's proposed FY 2019 budget aspires to emphasize departmental efforts to expand advocacy for and remove regula-

tory barriers facing the commercial space industry. This budget proposed spending \$1.8 million for NOAA's Office of Space Commerce and the same amount for the Commercial Remote Sensing Regulatory Affairs Office, representing an increase from the \$1.2 million level of FY 2017. Ross asserted this would enable Commerce to execute directives from the Trump Administration and National Space Council to advance American commercial space industry leadership. He went on to assert that Commerce is conducting a major regulatory analysis to produce an updated remote sensing licensing process to facilitate this industry's growth, that the administration has designated Commerce as the new lead civil agency for space traffic management and space situational awareness, and that administration policy will strive to ensure that the U.S. is the flag of choice for space business [51].

NASA Administrator James Bridenstine testified before the Science Subcommittee on May 23, 2018. He faced criticism from senators Brian Schatz (D-HI) and Jeanne Shaheen (D-NH) for the Trump Administration attempting to cut earth science and next-generation transportation programs from NASA's budget while also expressing concerns such as Government Accountability Office (GAO) reports documenting repeated problems with the JWST. Bridenstine responded by noting that NASA's budget request adheres to National Security Space Policy Directive 1 intent for "an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities" [52].

Bridenstine went on to stress the multiple programs the NASA was striving to accomplish in its FY 2019 budget request. Examples include spending \$150 million to support the commercial low Earth orbit industry, planning to launch an unscrewed deep space exploration mission in fiscal year 2020 with a second follow-up mission in 2023, developing in-space infrastructure for long-term lunar exploration and development while also facilitating exploration of Mars, enhancing the Human Research Program to examine the effects of spaceflight on the human body; and exploring robotic manufacturing and assembly in space [53].

On March 17, 2017, the Senate Armed Services Committee's Subcommittee on Strategic Forces held a hearing on military space organization, policy, and planning. Subcommittee Chair Deb Fischer (R-NE) noted numerous governmental studies indicating that Department of Defense DOD space responsibilities are distributed across nearly 60 entities including DOD, the Executive Office of the President, and intelligence agencies. She also noted that none of the 37 nominees of the March 2017 Air Force promotion list were career space professionals. Air Force Secretary Heather Wilson mentioned that the Air Force was working to improve its space training and streamline its space acquisition processes. The witness Air Force Chief of Staff General David Goldfein commented that space superiority, similar to air superiority, is not an American birthright but requires vigilance and action to ensure maintaining national space superiority. He then asserted, "we are in a strategic shift from treating space as a benign domain from which we monitor, sense, and report into a warfighting domain from which we fight should a war start in space or extend into space." Responding to a question from Mike Rounds (R-SD) about who the US closest adversaries in space are, Goldfein noted that both China and Russia are the countries observing US military space capabilities since Operation Desert Storm while also stressing that they have seen how the U.S. uses space and its dependence on the space as a military operational domain [54].

A March 20, 2018, Senate Armed Services Committee hearing focused on STRATCOM fiscal year 2019 congressional budget request. STRATCOM Commander General John Hyten noted these forces are globally distributed encompassing space, air, cyber, sea, land, and underground components. Hyten noted emerging space challenges to the U.S. include hypersonic weapons that barely enter space and then turn downward flying at high speed, with both China and Russia aggressively pursuing this capability and responding to Bill Nelson (D-

FL) about a hypothetical space corps saying he thinks there will eventually be a space corps or force but that now is not the right time while approving of President Trump's description of space as a warfighting domain. Hyten went on to stress that improving sensor capabilities to track, characterize, and understand where threats come from is imperative, requiring a new space sensor architecture [55].

The Commerce, Science, and Transportation Committee and its Space Science and Competitiveness Subcommittee maintained a busy oversight agenda during the 115th Congress. This included coverage of similar space policy issues to its House counterpart while also dealing with the controversial nomination of James Bridenstine as the NASA administrator. A May 23, 2017, hearing by this subcommittee examined how the OST might impact US space settlement and commerce. Numerous witnesses testified at this hearing representing academic, legal, and commercial space interest perspectives. Subcommittee Chair Ted Cruz (R-TX) noted that the fifty years since this treaty had seen most space activities be government sponsored while noting that the U.S. is poised to lead burgeoning commercial space activity in which American companies may land on the moon's surface, service satellites, and mine asteroids containing platinum and other precious metals with potential value of trillions of dollars. He went on to note the potential for conflicts as countries and commercial interests will compete for resources in the universe and that it is important for Congress to determine actual US international obligations to advance domestic policy and further US national interests [56].

A letter from the interest group Secure World Foundation maintained that the U.S. leads the world in commercial satellite launches, that 66% of more than 250 identified investors in space start-ups were U.S. based, and that restrictions on further innovation and space commercial development come from US law instead of the OST. Secure World noted that satellite export controls have caused the U.S. to lose a significant portion of global market share, that restrictions on several categories of on-orbit and remote sensing activities have not enabled US industries to participate in these activities enabling foreign competitors to gain competitive advantages, and that many types of emerging commercial space activities do not fall within existing national licensing authorities [57].

Mobius Legal Group founder James Dunston observed the space industry now approaches \$350 billion in annual revenue, earned primarily from commercial satellite services, and the emergence of new-generation launch vehicles with fly-back first boosters and potentially emerging fly-back second stages which could produce drastic launch cost decreases. He urged Congress to address the governmental and private sector relationship of OST Article VI and stressed that federal law allows Americans to engage in space activity and that space entrepreneurs need permission from multiple federal agencies including DOD, Federal Aviation Administration FAA, Federal Communications Commission FCC, the NASA, and the NOAA to conduct space launches, to report to state and local authorities on launch environmental impact assessments, and to obtain permits to transport vehicles across state and county lines by clarifying cumbersome, burdensome, and inconsistent regulations [58].

University of Nebraska Law School Professor Matthew Schaefer praised Congress for enacting the 2015 U.S Commercial Space Launch Competitiveness Act, stressing that there can be property rights in extracted resources reflecting long-standing US interpretation of the OST. He also said this enhanced international space law continuity and enables the U.S. to have an OST-compliant regime consistent with the spirit of permissionless innovation facilitating Internet economic growth and success [59].

Congressional committee oversight of US space policymaking can also produce hyperpartisan political debate and rhetoric as demonstrated by the controversial 2017–2018 nomination and eventual confirmation of James Bridenstine as the NASA administrator. Bridenstine had served as a congressional representative from Oklahoma from 2013 to 2018, possessed significant military experience, and served on

the House Science Committee and its Space Subcommittee [60]. This committee held Bridenstine's confirmation hearing on November 1, 2017. In his opening statement to the committee, Bridenstine stressed opportunities he saw facing the NASA including launching US astronauts on American rockets from American soil; the first combined launch of the SLS and Orion Multi-Purpose Crew Vehicle; the possibility of sending humans beyond Earth's orbit for the first time since 1972; and the emergence of the commercial space industry; transitioning the ISS, following 2017 NASA Transition Authorization Act requirements to get humans to Mars; and furthering JWST and Parker Solar Probe development while providing wise stewardship of taxpayer dollars [61].

Bridenstine's critics maintained his lack of formal academic scientific background did not qualify him to be the NASA administrator. He was also criticized for being divisive, for not adhering to what many consider the "scientific consensus" on climate change, and for adhering to traditional views on marriage and sexual morality. Bridenstine's nomination passed the Commerce, Science, and Transportation Committee by one vote on a party-line basis on November 8, 2017, and January 18, 2018. During April 18, 2018, Senate floor debate on this nomination, Committee ranking member Bill Nelson (D-FL) criticized Bridenstine for attacking senators from his own party and expressing concern that his military pilot service did not qualify him to be the NASA administrator and that NASA leadership requires someone who understands earth science. Patty Murray (D-WA) criticized Bridenstine for his support of traditional marriage and claimed he should not be put in charge of NASA's diverse workforce, and Ed Markey (D-WA) claimed Bridenstine's purported views on science and social diversity made him unqualified to lead the NASA [62].

Bridenstine's defenders, such as Commerce, Science, and Transportation Committee Chair John Thune (R-SD), noted that Bridenstine's nomination had received bipartisan support from the space community with more than 50 space-related leaders and organizations submitting supportive letters, including Rep. Ed Perlmutter (D-CO), former NASA Administrator Sean O'Keefe, and astronaut Buzz Aldrin. Space Subcommittee Chair Cruz criticized "cynical politicians attempting to malign his character, despite the fact he has spent his entire adult life in public service," defended his military accomplishments as a fighter pilot as earning the respect of those serving under his command, noted that a number of NASA astronauts had similar professional backgrounds to Bridenstine, and noted that he would work to ensure the NASA maintains American space leadership and implement the bipartisan congressional commitment to restore the U.S.-manned space program and go to Mars [63].

Debate on Bridenstine's nomination continued on April 19, 2018, with support and opposition falling along party lines. His supporters, including James Lankford (R-OK), stressed Bridenstine's extreme attentiveness to space issues, wanting the NASA to focus on a long-term vision and that he had the support of Oklahoma's congressional delegation. Bridenstine's nomination was finally confirmed this day on a 50-49 party-line vote [64].

July 25, 2018, saw the Space Subcommittee conduct a hearing on possible American landing on Mars. United Launch Alliance (ULA) President Tory Bruno stressed that every US mission to Mars since then had been ULA launched including the 2011 Curiosity Mission, the 2013 Mars Atmosphere and Volatile Evolution spacecraft, the 2018 Mars Interior Exploration Insight Lander, and a forthcoming 2020 mission to gather knowledge and demonstrate technologies concerning the human challenges or Mars missions [65]. Explore Mars CEO Chris Carberry contended that emerging technological developments and government support makes it possible for the U.S. to land on Mars in the 2030s. He noted several realistic and efficient concepts for landing humans on Mars have been proposed by the NASA, industry and commercial stakeholders, and other interested entities. Carberry also noted three possible scenarios for missions to Mars including "sortie-like" missions involving a two-week surface comparable with Apollo lunar missions; semipermanent base or field camps staying a year and a half compar-

able with early Antarctic exploration; and sustained permanent habitation comparable with current Antarctic exploration, possibly setting the stage for permanent settlement [66].

Former NASA Deputy Administrator and MIT Astronautics Professor Dava Newman noted that getting boots on Mars requires determining optimal roles for the NASA, the commercial space sector, and international partners. Newman advocated the NASA needed better integration of its Science, Space Technology, and Human Exploration portfolios, recommending a synergistic Mars Program Office across all three portfolios with sufficient budgetary support. She concluded by stressing that 2020's technology investments in advanced propulsion, smart habitats, advanced human machine autonomy, and novel radiation protection for a completely self-supporting journey are necessary for achieving seamless human-machine interoperability for scientific exploration. Former NASA Astronaut Dr. Peggy Whitson observed sustainability will be a key factor in future exploration success and expanding humanity's solar system presence. Stressing that water purification and recycling technologies developed on the ISS were critical for continued lunar and Martian exploration and also relevant to areas on earth with limited clean water resources, she also emphasized that space science research advances in bone loss and exercise mitigation, spaceflight neuro-ocular system changes, nutrition requirements, host-microorganism interactions, immune response, cardiac stem cells, and many other research areas have produced benefits that could be applied to expanding human presence beyond Earth [67].

An August 1, 2018, Space Subcommittee hearing examined the search for extraterrestrial life and how science can be used to explore the solar system and make new discoveries. MIT Planetary Science, Physics, and Aerospace Engineering Professor Sara Seager noted there is no evidence of life beyond Earth while stressing that there are potentially a few dozen exoplanets orbiting stars which may have necessary temperatures for life owing to their distance from heating by a host star. Seager also noted that the NASA's TESS, launched on April 18, 2018, would survey stars for transiting exoplanets with four specialized telescopes with a 100-mm aperture with each covering  $24^\circ \times 24^\circ$  on the sky representing an approximate equivalent of nearly 50 full moons. Princeton Astronomy Professor David Spergel commented that NASA satellites have enabled discovery of thousands of exoplanets, detecting optical counterparts of emerging neutron stars with gravitational waves traveling for billions of light years, and were tracing the large-scale distribution or dark matter and dark energy.

Smithsonian National Air and Space Museum Director Ellen Stofan asserted that studying life origins on Earth is foundational to studying life elsewhere. She stressed astrobiologists have found life in extreme terrestrial environments including volcanic lakes, sulfur springs, and at the top of the stratosphere. Consequently, she maintained that the first step for identifying environments potentially capable of supporting microbial life in conditions similar to early Earth includes liquid water, a nutrient source, and an energy source, with four highly likely targets of these attributes including Mars, Jupiter's moon Europa, Saturn's moon Enceladus, and Saturn's moon Titan also being potentially capable of supporting life. NASA Associate Administrator for Science Mission Directorate Thomas Zurbuchen announced that the forthcoming Parker Solar Probe launch would be the first spacecraft designed to provide the closest-ever observations of a star. He also mentioned this craft's measurements would transform understanding of the sun's corona, expand knowledge of the solar wind's origins and evolution, enhance the ability to forecast space weather changes affecting life on earth and its technological infrastructure, and gain augmented understanding of how stars such as earth affect the potential habitability of planets around other stars [68].

## 2. Analysis

This work demonstrates the multifaceted legislative and oversight activities of congressional space policy committees. In its 115th Congress activity report, the House Armed Services Committee noted

that the FY 2018 (P.L. 115-91) and FY 2019 (P.L. 115-232) defense authorization acts noted space has become a warfighting domain. These statutes also sought to streamline Air Force acquisition authorities within a single accountable space force organization and to enhance space warfighting readiness, space launch speed and dependability, supply chain security for certain space programs, and use small- and medium-size buses for strategic payloads. Comparable military space policy oversight activity also characterized the Senate Armed Services Committee during this congressional session [69].

The 115th Congress space policy legislation enacted into law by the House Science, Space, and Technology Committee included Public Law 115-7 Inspiring the Next Space Pioneers, Innovators, Researchers, and Explorers Women Act enacted on February 28, 2017; Public Law 115-10 the National Aeronautics and Space Administration Transition Authorization Act of 2017 enacted on March 21, 2017; and Public Law 115-26 Weather Research and Forecasting Innovation Act of 2017 enacted on April 18, 2017. Legislation passing the House only during this session include H.R. 1159 the United States and Israel Space Cooperation Act; H.R. 2809 the American Space Commerce Free Enterprise Act; H.R. 4250 Women in Aerospace Education Act; and H.R. 5346 Commercial Space Support Vehicle Act. This congressional legislative activity also enhances the growing corpus of statutory law covering space policy and the commercial space industry, which is now part of the recently created Title 51 of the United States Code documenting US space policy legal authorities. Subsequent years will see congressional space policy committees engaging in further expansion and revision of this sector of legal activity along with oversight of the regulatory regime seeking to apply this statutory codification to governmental and commercial space activities [70].

During the 115th Congress, the Senate Commerce, Science, and Transportation Committee's Space, Science, and Competitiveness Subcommittee held 10 hearings addressing civil space policy matters including attempting to streamline regulations for the commercial space sector to enhance its global competitiveness. The full committee considered 356 bills, 28 resolutions, and 1133 nominations, with NASA Administrator Bridenstine's being the most important and controversial, including promotions, received 2371 executive branch communications, held 15 executive sessions, and filed 69 committee legislative reports. Examples of legislation considered by this committee included amending H.R. 4254 the National Science Foundation Authorization Act of 2002 to strengthen the aerospace force work pipeline by promoting the Robert Noyce Teacher Scholarship Program and NASA Intern and Fellowship Opportunities for women; H.R. 5345 designating NASA's Marshall Space Flight Center to provide leadership for the US rocket propulsion industrial base; H.R. 5346 amending US Code Title 51 to provide licenses and experimental permits for space support vehicles; S. 3277 reducing regulatory burdens and streamlining commercial space activity processes; and S. 3799 reauthorizing NASA programs [71].

### 3. Conclusion

Congressional legislation and funding create and partially sustain the US civilian, commercial, and military space infrastructure at geographically dispersed locations. Congressional committee activity is an essential resource for understanding US government space policymaking and federal policymaking in other arenas. These committees consider legislation on civilian and military space policy matters, witness testifying before these committees represent varying levels of expertise and political perspectives, present sworn testimony as if they were appearing before a court of law, and witness questioning by committee members at least partially reflecting some level of public opinion on space policy issues because representatives and senators are directly elected by the public [72].

At their best, congressional committee space policy oversight activity can provide scholars and the general public with insightful and substantive information on space policy issues affecting the U.S. and

other countries. At its worst, activity by these committees can reflect political posturing as demonstrated by the hyperpartisan nature of Bridenstine's nomination and reflect congressional parochialism as members of congressional oversight committees and subcommittees may seek to promote federal programs and financial spending to benefit their individual congressional districts and states at the possible expense of overall space policy program performance. Such oversight can also see congressional members try to preserve their electoral viability by supporting programs in their states or districts; even these programs have continual performance problems [73].

The 116th and subsequent congressional sessions will see space policy committees continuing to oversee and influence US civilian and military space policymaking. Continued emphasis will be placed on space policy programs administered by the NASA, as chronicled in this analysis, and on emerging proposals including the Trump Administration's military space force proposal which the Senate Armed Services Committee examined in an April 11, 2019, hearing on this topic featuring witnesses Acting Secretary of Defense Patrick Shanahan, Secretary of the Air Force Heather Wilson, Joint Chiefs of Staff Chair General Joseph Dunford, and STRATCOM Commander General John E. Hyten. Careful analysis of congressional committee space policymaking is essential for all space policy students, private sector contractors, scholars, and the general public. Elements of this analysis must include the value these programs provide for taxpayer dollars, their scientific merit, and whether they meet compelling national security interests. This analysis is critical for those interested in gaining enhanced understanding of the strengths, weaknesses, and controversies involved in US space policy programs due to Congress' funding, legislative, and oversight powers and authorities and congressional interactions with presidential policymaking aspirations along with executive branch and independent agencies involved in space policymaking including the Commerce and Defense Departments, the NASA, and intelligence community [74].

### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.spacepol.2019.101359>.

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