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A SPACE POLICY PRIMER: KEY CONCEPTS, ISSUES, AND ACTORS

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ABOUT THE CENTER FOR SPACE POLICY AND STRATEGY

The Center for Space Policy and Strategy is dedicated to shaping the future by providing nonpartisan research and strategic analysis to decisionmakers. The Center is part of The Aerospace Corporation, a nonprofit organization that advises the government on complex space enterprise and systems engineering problems.

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SPACE POLICY PRIMER

Key Concepts, Issues, and Actors

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Foreword

Space policy shapes the direction of technological and economic developments that are increasingly integrated with a wide range of human endeavor. While many of the implications of activity in space are understandably invisible to the average person, an astounding range of human activity relies on space capabilities. This is increasingly true around the globe, and especially true in matters affecting national security. However, the diversity of the space community and its technical underpinnings make it challenging for newcomers to get a holistic understanding of the formulation, implementation, and implications of space policy. Even for technical experts in one of the many scientific and engineering disciplines central to space activity, it can be hard to make sense of how underlying policy direction is fundamentally shaping the art of the possible. That is why there is great value in a primer that concisely identifies key concepts, issues, and organizational actors involved in space policy.

It is sometimes said that the formulation of policy and law is a “sausage-making” process so unappealing that people are better off not knowing what goes into it. At the Center for Space Policy and Strategy, it is perhaps not surprising that we disagree. Knowing is better than not knowing—it drives understanding, which is every bit as critical for citizens in a democracy and for those in the press who keep them informed as it is for the government and business leaders working in the field.

This primer lays out the essentials on the participants and processes of space policy, with minimal jargon and acronyms. We hope this primer becomes a useful reference document for everyone from space policy novices to those with extensive experience with space issues. It should be especially useful as a source of introductory readings for university and professional military education classes on space topics. While the primer is somewhat U.S.-centric, it reflects the global environment and should be useful for non-U.S. observers seeking to understand the complexities of U.S. space policy.

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Introduction

A wide variety of difficult space policy questions face the United States and other spacefaring nations.

At a time when plans are being made by the United States and others to return humans to the moon and eventually reach Mars while also exploring more distant worlds robotically, what should the overall goals of America's civil space exploration program be, and what strategy is most conducive to achieving them? What role will international partners play in such endeavors? And how best can new developments in the commercial space sector be leveraged in service of space science and exploration?

The revolution in the commercial space sector also drives a number of questions. Current regulatory systems are not adequately equipped to manage a world of private reusable rockets, large-scale constellations of satellites in low Earth orbit (LEO), asteroid mining, and in-space servicing. What domestic and international governance structures and internationally accepted guidelines, standards, and best practices need to be in place to prevent misunderstanding among nations and to protect the sustainability of the space environment? How can the interests of industry, free-markets, and national security best be balanced when they come into conflict?

The United States national security space enterprise also faces a number of challenging questions. The increasing capability of rivals to threaten space assets with harm and to exploit space for military advantage is being used to argue for more rapid development of more survivable space capabilities. Is the United States' current military space acquisition system up to the task? Are U.S. military space operations organized effectively, or are new institutional structures required to prepare for conflict that extends into space? And how should U.S. allies and partners share the burden of collective defense in space?

The U.S. military also plays a vital role in tracking space debris and monitoring traffic in space. As malevolent threats to U.S. national security space assets multiply, should the military continue to play a leading role internationally in space situational awareness (SSA) data sharing, or should a U.S. civilian agency take on the responsibility of sharing that data with the rest of the world and establish a concept for space traffic management (STM)? How might the rest of world react to such a U.S. initiative and interface with it?

Navigating these and many additional pressing challenges will require concerted effort by policymakers working in many fields. This primer provides some key concepts for categorizing and understanding space activities, provides an overview of international space law, and touches upon some common rationales which help justify the huge investments required for space activities. It also provides a brief sketch of how the U.S. government is organized to address these difficult space policy questions. Ideally, this primer will provide the reader with the foundation upon which a comprehensive understanding of the complex issues surrounding U.S. national space policy may be built. More detailed discussions about these and other space policy issues may be found in other works by the Center for Space Policy and Strategy, especially Major Policy Issues in Evolving Global Space Operations[*] by James A. Vedda and Peter L. Hays, which helped inspire the creation of this primer.

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[*]The full paper can be found at https://aerospace.org/paper/policy-issues-evolving-global-space-operations.

Key Concepts and Nomenclature

This chapter describes several key concepts by introducing some common nomenclatures used in thinking about and describing space activities.

Space Activity Categories

Space activities are often divided conceptually into three categories: *human spaceflight*, *space science*, and *spaceflight applications*.

Human spaceflight includes any activity that places humans in space, including the International Space Station, and efforts to send humans to the moon and Mars. Historically, the American public has sometimes equated the U.S. space program with human spaceflight since it was at times the most visible space activity, though in recent years robotic exploration missions have generated extensive public interest.

Space science involves using spacecraft to make scientific observations of the Earth, celestial bodies, and astronomical phenomena.

Space applications are practical services performed by spacecraft, including navigation, communications, weather and land monitoring, defense, and intelligence gathering. Although space applications like the global positioning system (GPS) and satellite communications are tightly integrated into the economy and critical for modern society, their association with space is largely invisible to users.

Space Activity Sectors

Space activities are also frequently divided conceptually into three different activity sectors: *civil space*, *commercial space*, and *national security space*.

Civil space consists of activities sponsored and conducted by civilian government entities. This includes the full range of space activities from agencies like The National Aeronautics and Space Administration (NASA) and the National Oceanographic and Atmospheric Administration (NOAA). Human space exploration, space science, and many space applications like weather monitoring are typically found within the civil space sector.

Commercial space consists of privately financed space activities conducted with a profit as the motivating force. This includes satellite manufacturing, launch services, satellite communications, commercial satellite imaging, and emerging enterprises such as space tourism. Commercial space has four characteristics: (1) private capital is at risk in development and operation, (2) existing or potential non-governmental customers, (3) market forces determine viability, and (4) primary responsibility and management resides with the private sector.

National security space, or simply *security space*, refers to military and intelligence space application activities funded and implemented by national security sector actors like the military services and intelligence agencies. More specifically, *military space* refers to the operational and tactical level use of space applications for warfighting purposes. *Intelligence space* connotes a more strategic-level use of satellites to provide national security decisionmakers with strategic information and to provide realtime tactical information to the warfighter.

These categories were not cleanly divided even in the earliest days of the Space Age, since many civil exploration missions were conducted by military personnel and various satellites and space stations blended national security and civil missions. Assets, technologies, and satellite data that can be shared between the civil and national security sectors are usually referred to as “dual-use” space capabilities. This form of blending is often done for economic efficiency reasons. In recent years, however, the divisions between these categories have blurred even further. Increasingly, civil and military governmental space actors are purchasing services like launch, communications, and Earth imagery from commercial space actors who provide those services to government and private customers alike. Universities and private laboratories are beginning to conduct space science activities previously only possible for governments, and commercial companies are building the capacity to independently put humans in space both as a service to governments and for tourism and other commercial purposes. Conversely, capabilities developed for military purposes like GPS have become deeply integrated in commercial activity. As the lines have further blurred, an increasing number of issues have become “cross-cutting” issues rather than remaining siloed in a particular sector. Nevertheless, the threefold sectoral division of space activities remains popular, and this conceptual framework will provide the organizational backbone for this primer.

Table 1: Space Sectors

Sector	Examples of Activities	Examples of Actors
Civil Space	International Space Station, Hubble Telescope, Apollo Program	NASA, NOAA
Commercial Space	Launch industry, Earth observation, communications, tourism, etc.	SpaceX, ULA, Iridium, Digital Globe, Virgin Galactic
National Security: Military	GPS, military communication satellites	Air Force, Army, Navy
National Security: Intelligence	Signals intelligence, reconnaissance	Intelligence agencies

U.S. Joint Military Functions

Joint Publication 3-14,[1] published by the office of the Joint Chiefs of Staff, identifies seven military joint functions that the U.S. Department of Defense conducts, and identifies how each of these functions relates to the military’s space role. The functions described provide a framework for understanding how the United States national security apparatus conceives its role in space. The identified functions are command and control, intelligence, fires, movement and maneuver, protection, sustainment, and information.

Command and control activities are the mechanism by which commanders exercise authority over their command. Space operations facilitate this activity by providing intelligence to inform commander decisions, secure communications to relay orders, and realtime awareness of the space and battlefield environments.

Intelligence is the function that integrates information to create an understanding of foreign nations, hostile threats, and areas of operation. Space operations enhance this function by providing information on adversary activities across multiple domains (including adversary space activities that may be a threat or presage ground actions), enhancing warfighter understanding of the environment, and alerting warfighters to the presence of signals intelligence (SIGINT) systems.

Fires consists of the use of weapons (which may be kinetic or nonkinetic) to induce effects on a target. In the space context, this can include fires in space or on the ground to degrade enemy space capabilities or enhance allied capabilities. Space systems also enable fires in other domains by providing navigation, communications, and target information.

Movement and maneuver activities are the movement of assets to secure an advantage before or during an engagement. Space assets, including space and ground systems, can be maneuvered, and usage of the electromagnetic spectrum can be changed to secure such advantages. Space operations also provide vital communication, navigation, and environmental awareness capabilities to support movement and maneuver of terrestrial assets.

Protection is the act of defending friendly assets from harm that would degrade their effectiveness. Space activities aid protection by monitoring the threat environment and allowing for preparation, while a variety of physical and strategic countermeasures protect space-related assets themselves from harm.

Sustainment consists of those activities that support the logistics needed to maintain operations over time. Space assets provide intelligence, communications, and navigation services that enable sustainment. Space assets are themselves sustained by space launch services to replace satellites and space operations to maintain them.

Information is the joint function that relates to the management, integration, and application of information. Space assets help transmit information and decisions based on that information.

Foreign Military Space Doctrine

As a point of comparison with U.S. views, the military space doctrine of China's People's Liberation Army (PLA) is useful to consider. PLA space and cyberspace activities are coordinated under the Strategic Support Force, a separate service branch established in 2016. The PLA has placed Chinese space activities into three categories: space attack and defense, [2] space deterrence, and space information support.[3]

Space attack and defense are described as "direct military confrontation" between opposing militaries. This includes counterspace activities conducted from the air and ground, defense of space assets against terrestrial attacks, space-based anti-missile capabilities, actions conducted between space assets, and attacks from space on terrestrial targets.[4]

Space deterrence consists of discouraging attacks on space assets by presenting a threat to opponent space assets. In China's case, this is done by developing counterspace weapons capable of disrupting perceived U.S. hegemony in orbit.[5] This form of deterrence appears more credible than nuclear deterrence because it poses concrete economic, political, and diplomatic consequences while falling short of the casualties of nuclear conflict.[6]

Space information support relates to the PLA's notion of "informatized warfare," the idea that the use of information is critical to modern war. In addition to offensive operations that limit opponent access to information, this involves space systems that provide information such as communications, environment monitoring, missile detection, and navigation support.[3]

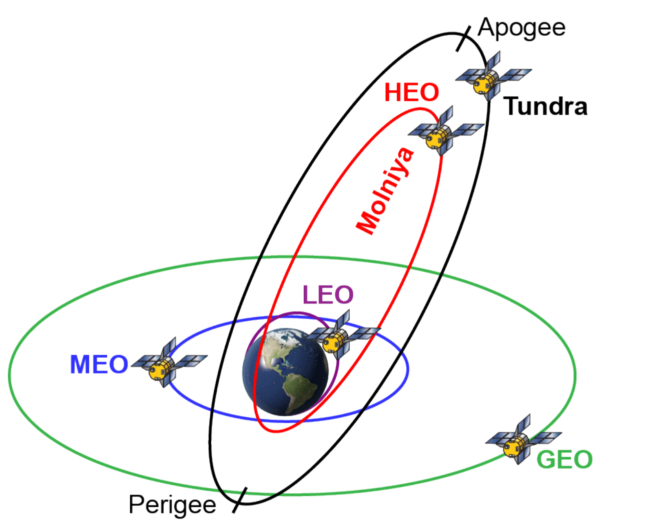
Satellite Orbital Characteristics

Space policy issues and key concepts are tightly intertwined with the mechanics of space flight, meaning that even an introductory policy overview must contain some background on the nomenclature used to describe the nature of satellite orbits.

Low Earth orbit (LEO) satellites operate from about 250 miles to 1,000 miles altitude. Medium Earth orbit (MEO) is generally considered to range from about 1,000 miles to 20,000 miles altitude. Geosynchronous/geostationary (GEO) satellites circle the equator at 22,236 miles altitude.

A satellite's "inclination" is also often used to classify satellites. If a spacecraft circles the Earth directly above the equator for its entire orbit, it has an inclination of zero degrees. The terms "geosynchronous Earth orbit" and "geostationary Earth orbit" (GEO) describe an orbit that has zero degrees inclination and an altitude of 22,236 miles. "Polar orbits" circle the Earth from pole to pole, with a 90-degree inclination. The International Space Station is at an inclination of 51.6 degrees, which is a "high-inclination" orbit greater than 45 degrees but much less than 90 degrees. "Sun-synchronous" orbits are near-polar in inclination; they assist overhead observation by allowing spacecraft to view specific latitudes on Earth at the same local time on each pass, producing images with the same sun angles.

Another classification is the shape of a spacecraft's orbit. Circular orbits, elliptical orbits, and highly elliptical (Tundra and Molniya) orbits are the most common. Figure 1 helps to visualize the different types of orbits.



Orbit		Altitude (km)	
		Perigee	Apogee
LEO: Low Earth Orbit		200-2,000; nominal: 500-1,000	
MEO: Medium Earth Orbit		2,000-GEO; nominal:10,000-20,000	
GEO: Geostationary Orbit		35,785	
HEO: Highly Eliptical Orbit	Molniya (12h)	~500	~40,000
	Tundra (24h)	~24,000	~40,000

Figure 1: Orbital characteristics.[7]

Rationales for Spaceflight

NASA historian Roger Launius identified five general rationales for spaceflight: (1) human destiny, (2) geopolitics/prestige, (3) national security, (4) economic competitiveness, and (5) scientific discovery.[8]

Human destiny rationales invoke the history of exploration found in human societies around the world. In the United States, there is a belief that the "frontier" shaped our national character, and the opening of a new frontier in space is vital to our country's continued success. Related rationales include the drive to understand "the heavens" and the desire to preserve the human species from threats on Earth by building new settlements in space. Advocates for human space exploration often employ this rationale to help justify the huge investments required for such space activities.

Geopolitics/prestige rationales relate to perceptions of country in the wider world. During the Cold War, space exploration became a tool of foreign policy for the U.S. and USSR, with each success seen as a vindication of each country's political and economic system and the Apollo 11 moon landing hailed as a victory for democracy and capitalism on an interplanetary stage. A nation's perception of its own leadership in space has played a key role in its space policy, as when President Nixon approved the space shuttle for fear of being seen as ceding the United States' leadership role.[9] Today, for many countries the prestige of having a space program is a significant driver to help justify the high costs of such an endeavor.

National security rationales focus on the unique opportunities that space provides for defense and intelligence purposes. International space law guarantees the right to fly in space over any nation, allowing states to maintain strategic, global, situational awareness, monitor their rivals, identify threats, ensure compliance with international treaty agreements, and thereby enhance deterrence and strategic stability. Space also enables long-distance communication, precision navigation, and weather forecasting that are critical for many different uses. As a result, some theorists consider space to be the new "high ground," analogous to strategic territory, control of the seas, or aerial superiority, giving significant advantages to those with access to space. While this analogy is imperfect, given the differences between a terrestrial hill and the orbital environment, the importance of space capabilities for national security is clear. Indeed, more and more countries are increasing their investments in dedicated military space capabilities and dual-use space capabilities.

Scientific discovery rationales emphasize the value of science both for its own sake and for potential applications it can create. Noting that the vast majority of the universe has yet to be explored, these rationales point to space as a limitless source of undiscovered knowledge.

Economic competitiveness rationales point to the concrete benefits that space programs bring to societies on Earth. Economically useful space applications, the development of a high-tech industrial workforce, and the creation of new industries motivate space activities in many countries. The 2010 U.S. space policy holds as a fundamental principle that "A robust and competitive commercial space sector is vital to continued progress in space. The United States is committed to encouraging and facilitating the growth of a U.S. commercial space sector that supports U.S. needs, is globally competitive, and advances U.S.

leadership in the generation of new markets and innovation-driven entrepreneurship."[25] Commercial space activities are thus vital for maintaining the *economic competitiveness* of a spacefaring country.

As well, a strong commercial space sector is critical to maintaining national security. Commercial space ensures the survival of a strong, skilled industrial base, which allows the United States government access to advanced technologies and satellite services that can be used for defense.

International Space Law and International Organizations

Foundational Documents

International Space Law is based upon four main agreements: the 1967 Outer Space Treaty, the 1968 Rescue and Return Agreement, the 1972 Liability Convention, and the 1975 Registration Convention.

The Outer Space Treaty (OST). The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, commonly known as the Outer Space Treaty, is the foundation of international space law. It provides several guiding principles for the use of outer space, the moon, and other celestial bodies. The common interest principle (Article I), the freedom principle (Article I), and the non-appropriation principle (Article II) establish that everyone is equally free to use outer space and no country can claim sovereignty over any part of it. The OST also acknowledges that the United Nations (UN) Charter and international law apply in outer space (Article III).[10]

The OST formally establishes the right of freedom of access to space for all nations, including the right of satellites to fly over any part of the Earth. Sovereign states maintain control of airspace over their territory and territorial waters but since the OST went into effect, that control does not legally extend upward into space.

The OST limits the military uses of space in only two respects:

1. Nuclear weapons or other weapons of mass destruction cannot be placed in orbit, on the moon or any other celestial body, or in outer space

2. The moon and other celestial bodies will be used exclusively for peaceful purposes; establishing military bases, testing weapons of any kind, or conducting military maneuvers on the moon and other celestial bodies is forbidden.[11]

The OST prohibits placing weapons of mass destruction in space, but it does not specifically prohibit other types of weapons in space. Furthermore, the OST does not prohibit anti-satellite weapons (ASATs). However, the OST also states "[i]n the exploration and use … Parties … shall conduct all their activities … with due regard to the corresponding interests of all other states."

With regard to the exploration of outer space (including the moon and celestial bodies), the OST makes clear that states must "avoid harmful contamination." Furthermore, if a state's space activity could potentially cause harmful interference with the space activities of other states (Article IX), the offending state is required to consult with the affected states.[12]

Rescue and Return Agreement. The Rescue and Return Agreement requires the rescue and prompt return of spacecraft personnel who land in international waters and in foreign countries. The agreement also requires states to return spacecraft parts that land in their territory if requested by the launching state.

Liability Convention. The Liability Convention and the OST make *states* responsible and liable for all activities that occur in outer space, even those conducted by civilians and private entities.[13] States therefore impose licensing and insurance requirements on commercial and private entities in order to provide authorization and continuing supervision as required in Article VI of the OST, and prevent potential costly liability expenses to the government.

The Registration Convention. The Registration Convention established a UN registry for space objects. It also requires states to establish national registries. However, the Registration Convention does not require very detailed or timely information, so its usefulness is often questioned.[14] The Registration Convention and the other treaties are sometimes criticized for their ambiguity on how the responsible state is to be identified. As commercial activities flourish, satellite and launch agreements are increasingly multinational, and it is more difficult to determine which government is required to register and/or is to be held liable for damages.[15]

Other Treaties. Other treaties also affect the use of outer space.

The 1963 Limited Test Ban Treaty prohibits nuclear explosions in outer space as well as in the atmosphere or underwater.[16]

The 1980 Environmental Modification Convention forbids hostile modification of the environment that might cause long-lasting, severe, or widespread environmental changes in outer space or the atmosphere.[17]

The New Strategic Arms Reduction Treaty (New START) between the United States and Russia prohibit interference with early warning systems and "national technical means" (NTMs); i.e., a reference to reconnaissance satellites but the term has never been officially defined. The purpose of these prohibitions is to facilitate the monitoring of treaty compliance and thereby reduce the risk of nuclear war.

The Hague Code of Conduct commits subscribing states to provide pre-launch notification of space launch vehicles launches and ballistic missile launches.

Key International Organizations

International Telecommunication Union (ITU). The ITU is a UN agency that governs the use of the radio frequency spectrum. The United States is an ITU member state. Additionally, the ITU assigns physical satellite orbital slots in geostationary orbit. The United States applies ITU rules to the U.S. military.[18]

United Nations Committee on the Peaceful Uses of Outer Space (COPUOS). COPUOS was established in 1959 as a forum for discussing international governance of outer space. The major space treaties listed previously were negotiated under the aegis of COPUOS, along with the Moon Agreement (which did not see widespread acceptance).[19] In recent years, COPUOS members have discussed issues like space debris management, creating guidelines for the long-term sustainability of space, and determining if more concrete solutions are necessary or possible.[20]

Conference on Disarmament. The Conference on Disarmament is an international forum outside of the United Nations dedicated to disarmament. Members have negotiated a variety of treaties limiting the use of nuclear, chemical, and biological weapons.[21] In recent years, Russia and China have proposed a draft Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects (PPWT). In short, the PPWT would ban the placement of weapons in outer space. The United States has resisted this effort, calling the treaty "fundamentally flawed" for ignoring ground-based ASATs that China has tested repeatedly, as well as arguing that it is un-verifiable.[22]

Inter-Agency Space Debris Coordination Committee (IADC). The IADC is an international committee composed of national space agencies. The IADC's goals are to facilitate research on space debris and enable international cooperation on responses and mitigation techniques.[23]

Committee on Space Research (COSPAR). COSPAR provides a forum for the international sharing of knowledge gained through space exploration. It also serves as a venue for discussing issues relating to the practice of space exploration, including the development of rules to prevent cross contamination of Earth and other celestial objects.[24]

U.S. National Space Policy

Current National Policy Documents

The National Space Policy of the United States of America, released in June 2010 by the Obama administration, describes current U.S. national space policy.[25] The document was amended by Space Policy Directive 1, issued by the Trump administration. In total, the Trump administration has issued three major Space Policy Directives (SPD 1, SPD-2, and SPD-3).[26]

Key U.S. national space policy documents are identified below.

Table 2: National Space Policy Documents

Policy	Year	Subject
Space Policy Directive 3, National Space Traffic Management Policy	2018	Space traffic management
Space Policy Directive 2, Streamlining Regulations on Commercial Use of Space	2018	Commercial regulation
Space Policy Directive 1, Presidential Memorandum on Reinvigorating America's Human Space Exploration Program	2017	Human exploration
Presidential Executive Order on Reviving the National Space Council	2017	Space Council
National Space Transportation Policy	2013	Space transportation
National Space Policy	2010	Overall policy
U.S. Space-Based Positioning, Navigation, and Timing Policy	2004	GPS
U.S. Commercial Remote Sensing Space Policy	2003	Remote sensing

Policy Goals

In the 2010 space policy, the Obama administration identified six goals for U.S. space policy:

1. *Energizing domestic competitive industries* concerns the advancement of the satellite manufacture, space launch, and space applications industries in the United States. Efforts associated with this goal include U.S. government support for new commercial launch providers[27] and increased utilization of rideshare and hosted payload capabilities where commercial and NASA spacecraft hitch rides to space together.[28]

2. *Expanding international cooperation* involves sharing data and promoting the peaceful use of space. This goal is manifested in the creation of SSA data-sharing agreements, increasing allied and partner contributions to military space activities, and international efforts to establish norms of behavior for outer space activity.

3. *Strengthening stability in space* focuses on domestic policy and international cooperation to mitigate the dangers of orbital collisions and debris, as well as protecting space systems and ground infrastructure more generally. This goal contributes to ongoing U.S. efforts to build international and interagency partnerships to share data and analyze threats to space and space-related assets.

4. *Increasing assurance and resilience of mission-essential functions* consists of protecting spacecraft from all forms of disruption, including space weather and hostile action. This goal reflects U.S. military efforts to increase the survivability of its space capabilities in the face of growing Chinese and Russian ASAT capabilities.

5. *Pursuing human and robotic initiatives* involves the exploration of the cosmos to achieve scientific, economic, and foreign policy benefits. This goal applies to NASA's space exploration efforts.

6. *Improving space-based Earth and solar observation* relates to improving capabilities to monitor weather and climate, land use, and other critical data. This goal applies mainly to NOAA's meteorological satellite program and the United States Geological Survey (USGS) Landsat program.

The 2010 policy revised elements of the Bush administration space policy issued in 2006, which was similar to the 2010 policy but included "Enabl[ing] unhindered U.S. operations in and through space to defend our interests there" as a goal.[29] Some viewed this goal and the guidelines delineated for its execution as overly confrontational, prompting a shift to a more open stance toward potential arms control regimes in space.[30]

The three space policy directives issued by the Trump administration to date amend and add national space policy, calling for long-term exploration of the moon before reaching for Mars,[31] streamlining the application process for commercial spaceflight activities,[32] and recommending the creation of a civilian space traffic management authority in the Department of Commerce.[26]

Actors that Generate U.S. Space Policy

Executive Branch. The President determines overall national space policy as well as civil, commercial, and national security space policy. Within the White House, since 2017, space policy is coordinated by the National Space Council, which is chaired by the Vice President and consists of the Secretaries of State, Defense, Commerce, Transportation, and Homeland Security along with the Director of National Intelligence, Director of the Office of Management and Budget, National Security Advisor, Administrator of NASA, Homeland Security Advisor, and the Chairman of the Joint Chiefs of Staff.[33]

In addition to the collaborative work of the National Space Council, the National Security Council (NSC), the Office of Science and Technology Policy (OSTP), the Office of Management and Budget (OMB), and the National Economic Council (NEC) draft policy for the President. In addition, the Administrator of NASA reports directly to the President.[34] The relative importance of various space policy actors varies by administration. The National Space Council, for example, was dormant under all previous presidencies other than John F. Kennedy and George H. W. Bush, while OSTP has had less influence during the Trump administration because it spent much of the first two years without an appointed leader.[35]

Legislative Branch. Designated Senate and House subcommittees deal with civil space issues. *Authorizing* subcommittees provide a policy framework for space activities and oversee their implementation. *Appropriations* subcommittees review civil space funding requests and appropriate funds to agency budgets.[36]

The main civil space authorizing subcommittee in the Senate is the Subcommittee on Space, Science, and Competitiveness, part of the Committee on Commerce, Science and Transportation. It handles issues concerning such organizations as NASA, the National Oceanographic and Atmospheric Administration (NOAA), the National Science Foundation (NSF), and OSTP. Military space authorization is under the purview of the Strategic Forces subcommittee of the Senate Armed Services Committee. Appropriations for civil space in the Senate are handled by the Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies, while appropriations for military space are under the jurisdiction of the Appropriations Subcommittee on Defense.

The main civil space authorizing subcommittee in the House of Representatives is the Subcommittee on Space and Aeronautics. It takes the lead role concerning issues related to NASA, NOAA and commercial space activities. It is a subcommittee of the Committee on Science. The Strategic Forces subcommittee of the House Armed Forces Committee handles military space issues. House Appropriations for civil space are handled by the Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies, while appropriations for military space are under the jurisdiction of the Appropriations Subcommittee on Defense.

In addition to the primary authorization and appropriations committees for civil and military space, there are a variety of other committees in the House and Senate that periodically make laws related to space. Special interest groups, lobbyists, and citizens also provide policy input to the elected and appointed decisionmakers that act in the organizations noted above.

Table 3: Congressional Space Authorization and Appropriations Committees

<table>
<tr><th colspan="2">Authorization</th></tr>
<tr><th>House</th><th>Senate</th></tr>
<tr><td>• Committee on Science, Space, and Technology
– Subcommittee on Space and Aeronautics
• Committee on Armed Services (HASC)
– Subcommittee on Strategic Forces
• Committee on Energy and Commerce
– Subcommittee on Communications and Technology
• Permanent Select Committee on Intelligence (HPSCI)
– Subcommittee on DOD Intelligence and Overhead Architecture</td><td>• Committee on Commerce, Science, and Transportation
– Subcommittee on Space, Science, and Competitiveness
– Subcommittee on Communications, Technology, Innovation, and the Internet
• Committee on Armed Services (SASC)
– Subcommittee on Strategic Forces
• Select Committee on Intelligence (SSCI)</td></tr>
<tr><th colspan="2">Appropriations</th></tr>
<tr><th>House</th><th>Senate</th></tr>
<tr><td>• Committee on Appropriations
– Subcommittee on Commerce, Justice, Science, and Related Agencies
– Subcommittee on Defense (HAC-D)</td><td>• Committee on Appropriations
– Subcommittee on Commerce, Justice, Science, and Related Agencies
– Subcommittee on Defense (SAC-D)</td></tr>
</table>

National Cross-Cutting Issues

While space activities are typically categorized into three distinct activity sectors—civil, commercial, and national security—many issues affect all three. Resolving these key issues requires effort from stakeholders from each sector.

Export Control

Space objects, no matter their intended purpose, are inherently "dual-use" and could be used for both civil and security needs. Early orbital rockets were simply intercontinental ballistic missiles with their payloads replaced by satellites and crew capsules. Spacecraft designed to observe weather patterns can also be used to collect intelligence on one's adversaries, and a satellite capable of repairing or refueling another satellite can just as easily be used for offensive maneuvers.

As a result, many U.S. space technologies are subject to U.S. export control regimes for national security reasons. The most notable of these are the International Traffic in Arms Regulations (ITAR). Though seen as necessary for ensuring national security, many in the field of commercial space feel that obsolete or overly restrictive rules impede American competitiveness internationally. Significant reforms were undertaken in 2014, but security and commercial actors differ on the path forward to resolve conflicts between the desire to boost commerce by easing regulatory burdens and the desire to preserve national security through export control.[37]

Space Situational Awareness and Space Traffic Management

As activity in space continues to grow, so too does the number of objects in orbit. Traveling at over 17,000 miles per hour at LEO altitudes, impacts between spacecraft would cause catastrophic damage. The threats posed by space debris, congestion, and possible attacks in orbit were made more apparent when a 2007 test of an anti-satellite weapon by the People's Liberation Army of China created thousands of pieces of debris,[38] and in 2009 when an operational Iridium telecommunications satellite was destroyed in a collision with a defunct Russian military spacecraft.[39] Managing the risks posed by this increasingly congested space environment is critical to ensuring the safety and sustainability of space operations. In order to address these threats, it is necessary to first identify and track spacecraft and debris. This allows satellites an opportunity to maneuver away from danger as well as making it possible to attribute attacks or acts of negligence to particular actors and craft an appropriate response. Indeed, awareness that inappropriate actions can be identified and attributed is a crucial part of deterrence, as actors will avoid causing damage to others if they know potential victims are able to identify culprits and respond in kind.

As part of the ongoing mission to protect their space assets, both NASA and the Department of Defense maintain well-developed space situational awareness (SSA) capabilities. As an effort to minimize the risk from space debris caused by others, the DOD also plays a space traffic management (STM) role, issuing conjunction warnings to satellite owners on a collision course with debris or other satellites. However, concerns about the appropriateness of using the military as an international space traffic monitor have spurred calls for the creation of a civil agency to accomplish the task of issuing conjunction warnings and possibly recommending evasive actions. Trump administration policy assigns that role to the Department of Commerce, which may also take on a number of responsibilities related to licensing and regulating commercial space activities.[40]

Radio Frequency Spectrum Management

Connectivity, fueled by the transmission of data over radiofrequency (RF) waves, is an increasingly important part of our daily lives. The RF spectrum is a limited resource however, and new users like 5G networks and large satellite constellations threaten to overwhelm it. Solutions to the problem have been suggested, including techniques for spectrum sharing between space and terrestrial users,[41] but agreeing on and implementing a particular solution will be a challenge.

Accommodating new and legacy users of spectrum to build a more connected world will require the cooperation of commercial companies and civil and military agencies who all utilize RF spectrum. As electromagnetism does not recognize political boundaries, solutions will also need to be international or regional in nature.

Civil Space Sector

Civil Space includes aspects of spaceflight funded and directed by non-military government entities. This tends to include human spaceflight, space science, and many space application activities. Examples include human spaceflight programs like Apollo and the International Space Station, robotic exploration missions like Curiosity and Hubble, and Earth observation programs like Landsat and geostationary operational environmental satellites (GOES).

U.S. Civil Space Implementers

National Aeronautics and Space Administration (NASA).[†] NASA is an independent agency that reports directly to the White House. NASA headquarters is located in Washington D.C., and much of the organization's internal activities are conducted at nine "field centers," located around the United States, plus the Jet Propulsion Laboratory, which is managed for NASA by the California Institute of Technology (see Appendix A). The NASA workforce fluctuates around 19,000 civil service employees. NASA grants and contracts also support a large workforce in the aerospace industry and in universities across the United States. NASA's FY 2019 budget request was $19.9 billion, with $20.7 billion having been appropriated for FY 2018.[42] [43]

National Oceanic and Atmospheric Administration (NOAA) National Environmental Satellite, Data and Information Service (NESDIS).[‡] NOAA's NESDIS program is the nation's primary source of space-based meteorological and climate data and is a leading source of such data for the world at large. NOAA-NESDIS spacecraft produce the satellite weather photos the public associates with television weather forecasts and Internet satellite weather maps. NESDIS headquarters is in Silver Spring, Maryland. The NESDIS budget request for FY 2019 was $1.6 billion.[44]

U.S. Geological Survey (USGS). [§] USGS is an agency of the Department of the Interior (DOI). It is responsible for the Landsat program, currently consisting of the Landsat-7 and Landsat-8 Earth observation satellites. NASA originally built and operated the Landsat satellites, but today the USGS operates the satellites and manages the data the satellites provide. Contractors operate Landsat spacecraft for USGS at its Earth Resources Observation and Science Center (EROS) in Sioux Falls, South Dakota, and at the NASA Goddard Space Flight Center.

Department of State, Bureau of Oceans and International Environmental and Scientific Affairs, Office of Space and Advanced Technology (OES/SAT).[**] OES/SAT handles international space issues and represents the United States in the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS). This UN committee developed the Outer Space Treaty and the other space-related conventions noted previously. The OES/SAT office also maintains the official United States registry of

[†]Further information on NASA can be found at its website, www.NASA.gov.
[‡]Further information on NESDIS can be found at its website, www.NESDIS.NOAA.gov.
[§]Further information about the Landsat program can be found at www.Landsat.USGS.gov.
[**]Further information about SAT can be found at www.state.gov/e/oes/sat/.

objects launched into outer space, oversees implementation of the Intergovernmental Agreement on the International Space Station, and supports U.S. civil space entities in upholding international agreements.

Department of State, Bureau of Arms Control, Verification, and Compliance (AVC), Office of Emerging Security Challenges (AVC/ESC).[45] AVC/ESC handles security issues relating to space, cyberspace, and the polar regions. In space, AVC/ESC pursues transparency and confidence building measures (TCBMs) meant to reduce tensions and enhance cooperation in space. AVC/ESC also participates in the formulation of military and intelligence-related space policy.

Key Civil Space Policy Issues

Commercialization of Low Earth Orbit. President Trump's FY 2019 budget proposal calls for an end to direct federal funding for the International Space Station by 2025, with funding allocated to developing a commercial alternative for low Earth orbit research in the interim.[46] Congress has expressed opposition to the proposed timeline,[47] but the ISS's hardware is expected to expire by 2030, and continued presence in LEO will require a replacement. What will that replacement look like? Who will fund it? The models of commercialization demonstrated by the Commercial Crew and Cargo Programs, where NASA pays for services provided, show some ways forward. Purely public and purely private models can also be envisioned, as well as many combinations in between.

Moon vs. Mars. Perhaps the longest-running debate in space exploration is the choice between returning to the moon or focusing the efforts and budgets of civil space agencies on reaching Mars. Each mission has different technical requirements and potential intermediary steps. NASA's goals have shifted in recent years. The Bush administration's Constellation program envisioned a base on the moon before expeditions to Mars began,[48] the Obama administration canceled Constellation for a "Journey to Mars" that skipped a lunar landing,[49] and the Trump administration again reversed course with its first directive on space policy calling for a return to the moon.[50] Will the next administration change the policy again, or will the current course prove politically sustainable? How will advancements in artificial intelligence (AI) affect the debate?

International Cooperation. Starting with the International Geophysical Year in 1957-58 that spurred the launches of Sputnik 1 and Explorer 1, space exploration has had an international character. The United States has cooperated with a wide array of countries to study the Earth, explore planets, and advance human spaceflight through projects like Apollo-Soyuz and the International Space Station. As the civil space goals and capabilities of the United States and partner nations evolve into the future, what shape will that cooperation take? How will the ISS partners fit into commercial models for LEO research? What role will other countries have in missions to Mars or the moon? The nature of international cooperation will play a key role in determining what the future of space science and exploration will look like.

Commercial Space Sector

Commercial Spaceflight can be defined in many ways. Some definitions consider commercial space to be any space activity conducted for profit, including for-profit activities conducted by government agencies. Definitions also differ as to whether ground systems like GPS receivers should be considered commercial space products.[51] For the purposes of this primer, commercial space refers to space activities with four characteristics: (1) private capital is at risk in development and operation, (2) there are existing or potential non-governmental customers, (3) market forces determine viability, and (4) the primary responsibility and management resides with the private sector.[52] The aerospace industry builds and sells satellites and launch vehicles and provides launch services for the civil space sector, the national security space sector, telecommunications companies, and remote sensing companies. The industry has grown significantly in recent decades: by 2018, commercial space activities accounted for 76 percent of total space spending.[53]

Commercial Space Landscape

Affordable Launch. Two key trends have enabled reductions in the cost of space launch. First, companies like SpaceX and Blue Origin have pioneered techniques to re-use launch vehicles, which has the potential for significant savings.[54] Several companies like Rocket Lab have also begun introducing small launch vehicles enabled by new technologies such as additive manufacturing. These small vehicles do not demonstrate the scale economies of larger rockets (e.g., cost per pound to orbit), but their lower total cost makes them attractive to some users.[55]

Smallsats and Large Constellations. Partially enabled by reduced launch costs, and partially by the ever-shrinking size of computer components, small satellites have paved the way for more diverse uses of space. Countries without significant space history like Mongolia and Ghana have been able to field satellites,[56] as have universities, high schools, and even middle schools through programs like NASA's Educational Launch of Nanosatellites (ELaNa).[57] Small satellites have also enabled a number of commercial ventures, including Earth imaging and communications services provided by huge fleets of cheap spacecraft in LEO.[58] Despite their applications, small satellites and large constellations also pose the risk of significantly increasing the quantity of debris in orbit.

New Space Applications. Recent years have seen serious proposals by commercial companies to undertake novel activities in space. *Space tourism*, which began in the early 2000s with a limited number of passengers paying high prices for a flight to the ISS, has continued to develop, with plans for private customers on suborbital flights by at least two well-financed companies.[59] Other new activities include *satellite servicing* with specialized spacecraft that would repair or refuel existing satellites to extend their lifetimes, and *commercial lunar and asteroid missions* that could provide data to space agencies and universities or even prospect for useful materials.

U.S. Commercial Space Governance Actors

Three key government organizations facilitate the commercial space sector:

1. **Federal Aviation Administration, Associate Administrator for Commercial Space Transportation (AST).** This office is part of the Department of Transportation. Its mission is to ensure protection of the public, property, and the national security and foreign policy interests of the United States during a commercial launch or reentry activity.[††] AST is responsible for issuing commercial launch licenses, licensing the operations of nonfederal launch sites, or "spaceports," and regulating key aspects of space tourism.

2. **Federal Communications Commission (FCC).** The FCC regulates interstate and international communications by radio, television, wire, satellite, and cable. Within the FCC, the primary organization responsible for space-related issues is the Satellite Division of the International Bureau.[‡‡]

3. **Office of Space Commerce.** As part of the Department of Commerce, the mission of this office is to foster an economic and policy environment that ensures the growth and international competitiveness of the U.S. commercial space industry.[§§] In 2018, the Office of Space Commerce was designated as the lead civil agency for commercial space regulatory affairs and is expected to undergo significant growth in the near future.[60] The proposed change would create a Space Policy Advancing Commercial Enterprise (SPACE) Administration reporting directly to the Secretary. It would absorb the responsibilities of the Office of Commercial Remote Sensing and Regulatory Affairs, which handles licensing and regulation of commercial imaging satellites, and would include representatives from other relevant components of the Commerce Department.[61]

Table 4: Examples of Current and Planned Commercial Space Activities

Activity Type	Example Companies
Satellite manufacturing	Northrop Grumman, Lockheed Martin, Boeing, SSL
Launch vehicle subsystem manufacturers	Aerojet Rocketdyne
Launch service providers	Arianespace, SpaceX, ULA, Northrop Grumman, Blue Origin
Telecommunication	Iridium, Intelsat, Eutelsat, DirectTV, Sirius XM
Earth observation	Planet, Digital Globe
Vehicle tracking	ORBCOMM, Spire
Space tourism	Virgin Galactic, Blue Origin
Satellite servicing	MDA, Northrop Grumman
Space station logistics	SpaceX, Sierra Nevada, Boeing, Northrop Grumman
Space stations	Axiom, NanoRacks, Bigelow Aerospace
Smallsat manifesting	Spaceflight Industries, NanoRacks
Lunar delivery and space resources	Astrobotic, Moon Express, Planetary Resources

[††]Further information on AST can be found on its website, https://www.faa.gov/about/office_org/headquarters_offices/ast/.
[‡‡]More information on the FCC's International Bureau Satellite Division can be found on its website, https://www.fcc.gov/general/international-bureau-satellite-division.
[§§]Further information on the Office of Space Commerce can be found on its website, http://www.space.commerce.gov/.

Key Commercial Space Policy Issues

Continuing Supervision. The Outer Space Treaty requires countries to continually supervise the activities of their citizens and organizations in space.[62] Until recently, those activities solely involved Earth orbiting satellites that rarely changed orbits: licenses for launch, communications, and Earth observations covered all potential use cases. With the advent of spacecraft servicing and deep space commercial operations, the picture has become more complicated. How will governments balance the need to maintain treaty obligations with the goal of supporting innovative uses of space?

Commercial Space Regulation. Although President Trump's second space policy directive called for the centralization of space regulatory activities in the Office of Space Commerce and the streamlining of regulations overall,[63] work remains to be done to implement those changes. Congressional authorization will be necessary to finalize a number of structural changes. How will these new regulatory activities be structured?

Evolving Foreign Competition. Many areas of the commercial space industry such as satellite manufacturing, space-rated components, and satellite imagery sales are developing increasingly competitive global markets. New technological developments are enabling new commercial actors or helping existing actors to compete in new ways. A particularly visible example of this can be found in the launch market. Following years of declining international sales, the rise of affordable launch vehicles has improved U.S. competitiveness on the global market. Nevertheless, the international context is complex. Europe, Russia, China, and India continue to offer commercial launch services on the international market, at times at rates that competitors argue are subsidized.[64] How will foreign competitors respond to U.S. efforts to increase market share? What must the United States do to prepare itself for a changing market?

National Security Sector

National security space refers to military and intelligence space application activities funded and implemented by national security sector actors, including the military and intelligence agencies. Generally, *military space* refers to the operational and tactical level use of satellite information for battlefield purposes. A few examples include military telecommunication satellites, enemy missile launch detection and warning satellites, and GPS satellites. *Intelligence space* refers to the gathering of data—through Earth observation, signal interception, and other space-based techniques—to inform national security decisions.

Key U.S. National Security Space Actors

U.S. Strategic Command (USSTRATCOM).[***] USSTRATCOM has operational control of U.S. military space assets. Under Strategic Command, the Joint Force Space Component Command (JFSCC) conducts space operations for the U.S. military. The commander of JFSCC serves as the single point of contact for military space operational matters. The commander of JFSCC is simultaneously commander of the Air Force Space Command (AFSPC).

One of the key services provided by the JFSCC is space situational awareness. The Joint Space Operations Center (JSpOC) at Vandenberg Air Force Base (AFB) detects, tracks, and identifies all orbiting objects. As of 2018, there were approximately 23,000 objects in orbit monitored by JSpOC, including orbital debris. JSpOC tasks the Space Surveillance Network (SSN) to observe the objects and uses the data to build a space catalog. JSpOC became the Combined Space Operations Center (CSpOC), intended to enable further allied cooperation, in 2018. [65]

Air Force Space Command (AFSPC).[†††] AFSPC is located at Peterson AFB, Colorado. AFSPC acquires and operates satellites, launch vehicles, missile launch warning sensors, space control systems, ground command and control facilities, the SSN, many major bases, remote sites around the world, and various other military space sector resources. Approximately 36,000 active-duty military and civilians, and contractor employees perform AFSPC missions.[66] See Appendix B for a description of operational units within AFSPC.

National Space Defense Center (NSDC) is an interagency operations center located at Schriever AFB composed of DOD staff, members of the intelligence community, and contractors. The NSDC is tasked with sharing information gathered by interagency partners about threats to satellites and coordinating responses to those threats.[67]

Air Force Space and Missile Systems Center (SMC).[‡‡‡] SMC is located at Los Angeles AFB , California, and is the Air Force's premier space acquisition center. SMC develops, acquires, fields, and

[***]Further information on USSTRATCOM can be found on its website, www.stratcom.mil.
[†††]Further information on AFSPC can be found on its website, www.afspc.af.mil/.
[‡‡‡]Further information on SMC can be found on the LA AFB website, www.losangeles.af.mil/.

sustains space and missile systems for the DOD. Programs focus on communications, navigation and tracking satellites, launch systems, and satellite control networks.

Air Force Space Rapid Capabilities Office (Space RCO). Space RCO, a new office formed from the former Operationally Responsive Space office (ORS), is tasked with rapidly developing new space capabilities to support the warfighter.[68] ORS was based at Kirtland AFB in Albuquerque, New Mexico.[69]

U.S. Army Space and Missile Defense Command/Army Forces Strategic Command (SMDC/ARSTRAT). SMDC is the Army command that supports the missions of USSTRATCOM and the JFSCC. It uses data collected from space by the Air Force, intelligence community, and commercial partners to enable its ground forces. The U.S. Army also provides a firm nexus between space and its missile defense mission. U.S. Army SMDC/ARSTRAT conducts space and missile defense operations and provides planning, integration, control and coordination of U.S. Army forces and capabilities in support of U.S. Strategic Command missions.[70]

Naval Network Warfare Command (NETWARCOM). NETWARCOM is the naval operational agent for space. Its responsibilities include acting as the U.S. Navy Functional Component for Space to U.S. Strategic Command; equipping, manning, and training the U.S. Navy for space; developing a U.S. Navy space cadre; and supporting space situational awareness activities.[71]

Space and Naval Warfare Systems Command (SPAWAR). SPAWAR develops, delivers, and sustains advanced cyber and space capabilities for the warfighters. SPAWAR, along with its system centers, space field activity, and its partnership with three program executive offices provides the hardware and software needed to execute warfighter missions. SPAWAR developed and operates the Mobile User Objective System (MUOS) satellite communications program. The Naval Research Laboratory is also heavily involved in naval space activities.

Service (Army, Navy, Air Force, Marines) Program Offices. Service program offices are responsible for developing, building, and deploying end-user equipment for the warfighter. There are multiple service program offices, each with their own authority and budget, that coordinate schedule, risks, and other interface requirements with their counterpart space segment program office.

Key National Security Space Policy Issues

DOD Space Governance. Many entities within the Department of Defense have an important stake in military space activities. The services, the Joint Staff, the intelligence community, and the Office of the Secretary of Defense all play significant roles in the acquisition, operation, and governance of military space. For decades, the DOD has grappled with designing the best organizational structure for maximizing U.S. military space activities for the warfighter and across these many stakeholders. As the biggest stakeholder, the U.S. Air Force has had the strongest voice over the years, but that may now be changing. At the time of this writing, the President directed the Department of Defense to immediately begin the process necessary to establish a Space Force as the sixth branch of the Armed Forces.[72] How will President Trump's directive be carried out? Once Congress weighs in on the issue, will the United States soon have a Space Force? What other forms could reform take? Emerging threats have created a new sense of urgency for resolving DOD space governance issues, and these questions will play an important role in space policy discussions in the coming years.

Threats, Deterrence, and Resilience. On February 13, 2018, Daniel R. Coats, Director of National Intelligence, warned Congress that "Russian and Chinese destructive ASAT [anti-satellite] weapons probably will reach initial operational capability in the next few years." Shortly thereafter, on March 15, 2018, Kenneth Rapuano, Assistant Secretary of Defense for Homeland Defense and Global Security, testified before Congress that Russia and China are fielding destructive and nondestructive counterspace weapons that threaten the safety, stability, and sustainability of the space environment, and U.S. national security.[73] How should the United States address these threats? The 2018 National Strategy for Space states, "The United States considers unfettered access to and freedom to operate in space to advance the security, economic prosperity, and scientific knowledge of the Nation to be a vital interest. Any harmful interference with or an attack upon critical component of our space architecture that directly affects this vital interest will be met with a deliberate response at a time, place, manner and domain of our choosing."[74] How should the U.S. deter or respond to harmful interference and attacks against its space architectures?

In this regard, military planners have begun examining ways to achieve "Space Domain Mission Assurance."[75] Space domain mission assurance activities are divided into three categories: (1) defensive operations that stop or deter an enemy's attack, (2) reconstitution to restore a capability after it has been damaged, and (3) resilience or the ability of a capability to withstand the effects of an attack. Resilience activities include concepts like disaggregation, where capabilities that have traditionally been bundled onto monolithic satellites are split onto separate satellites in order to limit single points of failure. Other concepts involved in achieving resilience are:

- Disaggregation
- Distribution
- Diversification
- Protection
- Proliferation
- Deception

These ideas will be incorporated into mission architectures, where strategies to achieve them and the relative costs and benefits of those strategies can be traded against each other in a deliberate and thoughtful way.[76] What balance of strategies is most useful for each mission? How will success in achieving mission assurance goals be measured? These questions will play an important role in determining what the national security space sector looks like in the years to come.

Commercial Alternatives. In recent years, commercial Earth imaging systems have become more widespread and more capable. While the national security community has been able to take advantage of these advances in some ways, the national security and commercial sectors sometimes come into conflict. Current policy places restrictions on the resolution of imagery commercial operators may offer to customers for fear that detailed images of some targets could pose a security threat. However, commercial operators in other countries may be less limited, making U.S. restrictions an impediment to economic competitiveness without providing a benefit to national security.[77] How can the United States balance security needs with the realities of the international market? What is the appropriate role for commercial imagery in the national security space community? Work has been done to address these questions, but they will continue to be relevant as technology improves.

Conclusion

The purpose of this primer has been to provide some key concepts and common nomenclature for thinking about space, provide an overview of international space law, and outline the key questions confronting the United States and other countries today. It also has provided a brief sketch of how the U.S. government is organized to address these difficult space policy questions and touched upon the rationales for investing in space activities. While this primer by no means touched upon every important concept, rationale, actor, or issue, it will hopefully make a small contribution to the discussion on how the United States, and the world, moves ahead in space. A more detailed discussion of some of the most pressing issues in space policy can be found in Major Policy Issues in Evolving Global Space Operations, written by Drs. James Vedda and Peter Hays. The Aerospace Corporation's Center for Space Policy and Strategy also produces a number of papers and other resources to aid further understanding of developments in space policy, which can be found on its website.[§§§]

[§§§]Further space policy resources can be found at the Center for Space Policy and Strategy's website: https://aerospace.org/policy.

Acronyms

AFB	Air Force Base
AFRC	Armstrong Flight Research Center
AFSCN	Air Force Satellite Control Network
AFSPC	Air Force Space Command
ARC	Ames Research Center
ASAT	anti-satellite weapon
AST	FAA Office of the Associate Administrator for Commercial Space Transportation
C2	command and control
COPUOS	United Nations Committee on the Peaceful Uses of Outer Space
CSpOC	Combined Space Operations Center
COSPAR	Committee on Space Research
DHS	Department of Homeland Security
DNI	Director of National Intelligence
DOD	Department of Defense
DSP	Defense Support Program
EROS	Earth Resources Observation and Science Center
ELaNa	Educational Launch of Nanosatellites
EU	European Union
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FY	fiscal year
GEO	geostationary orbit
GNSS	global navigation satellite system
GOES	geostationary operational environmental satellite
GPS	global positioning system
GRC	Glenn Research Center
GSFC	Goddard Spaceflight Center
GSO	geosynchronous orbit
GTO	geostationary transfer orbit
HEO	high Earth orbit
IADC	Inter-Agency Space Debris Coordination Committee
IGY	international geophysical year

ISS	International Space Station
ITAR	International Traffic in Arms Regulations
ITU	International Telecommunication Union
JFSCC	Joint Force Space Component Command
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
JSpOC	Joint Space Operations Center
KSC	Kennedy Space Center
LARC	Langley Research Center
LEO	low earth orbit
MDA	MacDonald, Dettwiler and Associates, a division of Maxar; *also* Missile Defense Agency
MEO	medium Earth orbit
MSFC	Marshall Spaceflight Center
MUOS	mobile user objective system
NASA	National Aeronautics and Space Administration
NEC	National Economic Council
NESDIS	National Environmental Satellite, Data and Information Service
NETWARCOM	Naval Network Warfare Command
NOAA	National Oceanic and Atmospheric Administration
NOG	National Operations Group
NORAD	North American Aerospace Defense Command
NSC	National Security Council
NSDC	National Space Defense Center
NSF	National Science Foundation
NTM	National Technical Means, reconnaissance satellites
OES/SAT	Office of Science and Advanced Technology
OG	Operations Group
OMB	Office of Management and Budget
ORS	Operationally Responsive Space office
OST	Outer Space Treaty/Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies
OSTP	Office of Science and Technology Policy
PAROS	prevention of an arms race in outer space

PLA	Chinese People's Liberation Army
PNT	position, navigation, timing
RF	radiofrequency
SBIRS	space-based infrared system
SIGINT	signals intelligence
SLS	space launch system
SMC	Air Force Space and Missile Systems Center
SMDC/ARSTRAT	U.S. Army Space and Missile Defense Command/Army Forces Strategic Command
Space RCO	Air Force Space Rapid Capabilities Office
SpaceX	Space Exploration Technologies Corporation
SSC	Stennis Space Center
SSL	Space Systems Loral, a division of Maxar
SSN	space surveillance network
SSO	sun-synchronous orbit
SW	space wing
TCBMs	Transparency and Confidence Building Measures
ULA	United Launch Alliance
UN	United Nations
U.S.	United States
USGS	U.S. Geological Survey
USSR	Union of Soviet Socialist Republics
USSTRATCOM	U.S. Strategic Command

Appendix A: NASA Field Centers

There are five mission directorates within NASA headquarters: Human Exploration and Operations, Space Technology, Mission Support, Science, and Aeronautics Research. The Trump Administration's 2019 budget proposes eliminating Space Technology as a separate directorate and moving its activities into Human Exploration and Operations with a small number of projects being transferred to Science.[78] NASA Headquarters is responsible for liaison with the White House, other Executive Branch agencies, Congress, NASA's international partners, the media, and the general public. Through its mission directorates, it develops the projects and programs and associated budgets that NASA's field centers are responsible for implementing.

NASA Field Centers

Johnson Space Center (JSC); Houston, Texas: JSC is the lead center for all NASA human spaceflight, including ISS activities, and bears responsibility for astronaut training. The mission control center (MCC) manages activity onboard the International Space Station. JSC is managing the development of the Orion spacecraft intended to send astronauts beyond LEO, and collaborates with commercial partners developing the vehicles that will soon send crew to the ISS.

Kennedy Space Center (KSC); near Titusville and Cocoa Beach (the "Space Coast"), Florida: KSC hosts launch facilities for the space launch system (SLS) intended to send humans beyond LEO as well as commercial rockets. KSC also coordinates launch vehicles carrying NASA payloads at Cape Canaveral Air Force Station in Florida, Vandenberg Air Force Base in California, and elsewhere. KSC also hosts facilities for the development of commercial crew and cargo spacecraft.

Marshall Space Flight Center (MSFC); Huntsville, Alabama: MSFC is responsible for key space launch and propulsion system development, including work on the space launch system.

Stennis Space Center (SSC); near Bay St. Louis in southern Mississippi: SSC is NASA's primary center for rocket engine testing and is the United States' largest rocket test complex.

Ames Research Center (ARC); Mountain View, California: ARC leads NASA research in information technology, nanotechnology, space biology, biotechnology, aerospace and thermal protection systems, and human factors. ARC also conducts research on the effects of gravity on living things and the nature and distribution of stars, planets, and life in the universe.

Goddard Space Flight Center (GSFC); Greenbelt, Maryland, a suburb of Washington D.C.: GSFC operates numerous scientific spacecraft including the Hubble Space Telescope, making GFSC the largest organization in the United States engaged in researching the Earth, the solar system, and the universe through satellite-based observations. GSFC also manages the operational space and ground network that supports the Human Spaceflight Program, as well as Earth orbiting missions, international, commercial, and classified and unclassified national missions.

Jet Propulsion Laboratory (JPL); California Institute of Technology, Pasadena, California: JPL is a federally funded research and development center managed and staffed by Caltech for NASA. JPL is responsible for interplanetary, deep space scientific and exploratory missions. Recent JPL missions include the Mars Science Laboratory rover, Curiosity; the Cassini mission to Saturn; and the Juno spacecraft orbiting Jupiter. JPL is also responsible for management of NASA's Deep Space Network, a global network of antenna complexes for controlling deep space spacecraft and retrieving data from them.

Armstrong Flight Research Center (AFRC); Edwards Air Force Base, California: AFRC, formerly Dryden Flight Research Center, is NASA's primary installation for flight research. In carrying out this mission, AFRC operates some of the most advanced research aircraft in the nation.

Glenn Research Center (GRC); Cleveland, Ohio: GRC is engaged in research, technology, and systems development programs in aeronautical propulsion, space propulsion, space power, space communications, and microgravity sciences in combustion and fluid physics.

Langley Research Center (LARC); Hampton, Virginia: Founded in 1917, LARC was the nation's first civilian aeronautical research facility. LARC leads NASA initiatives in aviation safety, small aircraft transportation, and aerospace vehicles system technology.

Appendix B: Air Force Space Command Operational Units

The 14th Air Force (14th AF)[79]

Headquartered at Vandenberg AFB, California, the 14th AF is responsible for the organization, training, equipping, command and control (C2), and employment of AF space forces to support operational plans and missions for U.S. combatant commanders and air component commanders. As the sole numbered air force for space, the 14th AF is the Air Force space task force to U.S. Strategic Command. The 14th AF comprises five wings and the Joint Space Air Operations Center (JSpOC).

1. **30th Space Wing: (30th SW).**[80] Located at Vandenberg AFB, California, the 30th SW conducts DOD space and missile testing, and supports the placement of satellites into high-inclination orbits from the launch facilities at Vandenberg.

2. **50th Space Wing (50th SW).**[81] The 50th SW is located at Schriever Air Force Base, Colorado. It is responsible for the operations and support of more than 185 Department of Defense satellites. The wing is composed of three groups:

    a. **50th Operations Group (50th OG).** The 50th OG operates DOD satellite systems, trains space operations crews, and provides operational support and evaluation functions for management of satellite operations centers and assigned ground stations. The group is composed of eight squadrons, including active-duty, Reserve, and Guard units stationed at Schriever AFB, Cape Canaveral AFS, and Vandenberg AFB.

    b. **50th Network Operations Group (50th NOG).**[82] The 50th NOG is the single focal point for operating and maintaining the $6.2 billion Air Force Satellite Control Network (AFSCN) and all 50th SW communications and computer systems. The group is composed of 4 squadrons, 4 detachments and operates from 12 locations.

    c. **50th Mission Support Group (50th MSG).** The 50th MSG primarily plays a base support role.

3. **21st Space Wing (21st SW).**[83] Headquartered at Peterson AFB, Colorado, the 21st SW provides missile warning and space control to North American Aerospace Defense Command (NORAD) and U.S. STRATCOM through a network of command and control units and ground and space-based sensors operated by units around the world.

    a. **21st Operations Group (21st OG).**[84] The 21st OG is located at Peterson AFB, Colorado, and is responsible for five Space Warning squadrons, four Space Control squadrons, and three Space Control squadron detachments.

4. **45th Space Wing (45 SW).**[85] Headquartered at Patrick AFB, Florida, the 45th SW supports the preparation and launching of U.S. government, civil, and commercial satellites from Cape Canaveral AFS, Florida.

5. **460th Space Wing (460th SW).**[86] Located at Buckley AFB, Colorado., the mission of the 460th SW is to provide global surveillance and missile warning data for theater and homeland defense.

    a. **460th Operations Group (460 OG).**[87] The 460th OG provides missile warning, missile defense, technical intelligence, satellite command and control, battlespace characterization and robust communications. The group operates the Defense Support Program (DSP) and Space-Based Infrared System (SBIR) satellites, which provide continuous global surveillance, tracking and targeting.

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