SPACE AGENDA 2021

STRATEGIC FORESIGHT: ADDRESSING UNCERTAINTY IN LONG-TERM STRATEGIC PLANNING

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The space domain and the policy issues surrounding it provide a key opportunity for the application of strategic foresight. Space is an increasingly complex physical, political, economic, and threat environment, with significant and rising uncertainty. Many space systems involve capabilities that are on the bleeding edge of technological development in a field rife with surprise from both forward leaps and setbacks. Future uncertainty in space is not just about technology, however. The geopolitics of great power competition in space, rising questions about the civil and commercial regulatory environment, and the state of the space workforce all pose challenges for future planning due to complex interactions, long lead times, and high costs of miscalculation. Strategic foresight can help because it takes a holistic approach to considering and preparing for what is possible instead of relying on existing conditions and trends to predict the future. Long-term vision is needed to navigate the toughest issues in space policy and help the United States proactively shape the path toward its preferred futures.

Introduction

If there is anything the COVID-19 pandemic has proven, it is that the future is ruled by uncertainty. Few could have predicted at the beginning of 2020 that the year would be shaped by a global pandemic causing disruptions to politics, economics, and the very foundations of human activity. The certainty that uncertainty will play a central role in the future indicates that policymakers looking forward must ask themselves not only what issues must be addressed but how they will approach planning and decisionmaking as a process. In order to navigate and even influence the paths created by disruption, we must examine our toolbox of methodologies for planning for the future.

The goal of foresight is not to predict the future, but to ensure we have adequately challenged our assumptions and are prepared for a variety of possible outcomes.

Strategic foresight is one such methodology. Strategic foresight is a varied set of tools and techniques that help to envision possible future outcomes so that we can make better decisions today.[1] Instead of bracing for disaster or change, strategic foresight helps us to envision preferred futures, identify key events and decision points along the path to those futures, and integrate uncertainty into the planning process from the beginning. The goal of foresight is not to predict the future, but to ensure we have adequately challenged our assumptions and are prepared for a variety of possible outcomes.[2] In this

framing, policymakers can accept and proactively shape to preferred futures through the uncertainties of life instead of simply responding to them after the fact.

Applying Strategic Foresight to the Key Issues of Space Agenda 2021

The *Space Agenda 2021* report has raised numerous key issues and decision points for policymakers to consider. The four major topics covered in the report—managing the growth of space traffic, national security space, space exploration and economic development, and shaping the future—are all complex and dynamic challenges that decisionmakers will face in the coming years.

Table 1 demonstrates the timeliness and complexity of the issues raised in *Space Agenda 2021*. Each chapter is summarized in terms of key technologies with the potential to affect the issue in coming years, cross-cutting factors shared with other chapters, and major opportunities and recommendations provided by the chapters' authors. The cross-cutting factors are particularly important because they demonstrate the integration of different challenges and opportunities across all facets of space activities. Although each chapter in *Space Agenda 2021* stands on its own, the topics discussed in each chapter often cannot be addressed without thinking about how the cross-cutting factors apply to other areas. The integration and complexity of space policy issues also bring to light several tensions that will need to be navigated as policymakers make decisions. These include balancing a number of dichotomies: regulatory oversight for security versus open paths for commercial growth; classification of sensitive information versus sharing for commercial and international partnerships; growth in activity versus space traffic management; moving as quickly as possible versus driving with purpose; the Space Force's role in international cooperation with partners versus use of force to defend national security; and actors who may be cooperative in some aspects and competitive in others.

One methodology within strategic foresight is the identification of key uncertainties and investigation into how they can affect the future. Two such uncertainties were uncovered through a special internal futures study led by Aerospace's Strategic Foresight Initiative. They are both deemed critical for the development of all four policy areas discussed in the report. Exploring potential implications against each issue is a helpful first step toward making actionable decisions for the next several years. The first critical uncertainty identified by our team is the degree to which space will be commercialized, and the second is the evolution and transformation of global power states. These two uncertainties focus on the form and function of actors involved in space and cut across a wide variety of space policy challenges (demonstrated in Table 1) as they relate to the two cross-cutting factors that appear in the most chapters ("expanding commercial capability and investment" and "global proliferation of space actors and space systems").

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Although this brief review cannot provide the answers or solutions to the challenges faced in space, it can help to provide questions that will start decisionmakers on the line of inquiry needed to develop strategies and policies that are adaptable, flexible, and inclusive of uncertainty instead of resistant to it.

Managing the Growth of Space Traffic | National Security Space | Exploration and Economic Development | Shaping the Future

Table 1: A Strategic Foresight Summary of *Space Agenda 2021* Chapters

Chapter Title	Key Technologies	Crosscutting Factors	Opportunities/Recommendations
Airspace Integration in an Era of Growing Launch Operations	◆ Faster space launch/"responsive" launch ◆ Reusable launch systems, launch system reliability	◆ Expanding commercial capability and investment ◆ Managing regulatory frameworks ◆ Environmental conservation and management ◆ Global proliferation of space actors and space systems	◆ Better data sharing between launch providers and National Airspace ◆ Air and Space stakeholder dialogue ◆ "Designed for demise" hardware
Space Traffic Management	◆ Space situational awareness ◆ On-orbit servicing ◆ Small satellites ◆ Cheaper launch ◆ Mission life extension ◆ Active disposal at end of life/active debris removal ◆ Large constellations ◆ Data fusion	◆ Expanding commercial capability and investment ◆ Managing regulatory frameworks ◆ Environmental conservation and management ◆ Global proliferation of space actors and space systems ◆ Collaborating with international partners ◆ Norms and behavior leadership	◆ Clearly establish organizational authorities and required resources for a national approach to space safety ◆ Establish mechanisms for international coordination and cooperation with government and commercial entities ◆ Develop clear definitions of nationally "acceptable" levels of safety and risk to enable development of norms of behavior and performance-based rules
Light Pollution from Satellites	◆ Cheaper launch ◆ Satellite materials ◆ Automation and miniaturization	◆ Managing regulatory frameworks ◆ Environmental conservation and management ◆ Expanding commercial capability and investment ◆ Global proliferation of space actors and space systems	◆ Establish an organized avenue for coordinated discussion on guidelines and mitigation strategies for satellite light pollution ◆ Regulators, astronomers, and industry should be in communication about their respective operational needs to explore options for building optical interference mitigation into existing constellation licensing application processes

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Organizing for Defense Space	Flexible systems that can accomplish multiple missions and continue to provide capability when contested	◆ Great power competition ◆ Global proliferation of space actors and space systems	Balance the missions that are supporting the joint force with missions focused on providing independent space capabilities.
Continuous Production Agility (CPA)	◆ Modularity, scalability, and interoperability in space systems ◆ Faster/responsive launch	◆ Expanding commercial capability and investment ◆ Great power competition ◆ Global proliferation of space actors and space systems	◆ Recognize a whole of government approach ◆ Break down monolithic, requirements-driven system into phases for an innovative development ecosystem, steady procurement, and deployment with smooth technology insertion ◆ Align USSF acquisition authorities for modular open standards architecture (MOSA) and CPA
Leveraging Commercial Developments for National Security Space	◆ Faster/cheaper/responsive launch ◆ Space situational awareness ◆ Large constellations ◆ Vulnerability of space-based systems	◆ Expanding commercial capability and investment ◆ Global proliferation of space actors and space systems ◆ Future markets and new space systems	◆ Consider which acquisition model (traditional, off-the-shelf, or purchased services) can best balance different challenges ◆ Continue efforts to explore commercial partnerships ◆ Revisit whether DOD organizational models need to adjust to better leverage commercial developments
Developing Foundational Spacepower Doctrine	Flexible systems that can accomplish multiple missions and continue to provide capability when contested	◆ Great power competition ◆ Norms and behavior leadership ◆ Global proliferation of space actors and space systems	◆ Future versions of Space Capstone Publication should build more explicitly from, and include, more dialogue with existing doctrine ◆ Consider interdependencies and holistic strategic contributions of space capabilities ◆ Flow Space Force organizational culture up from fundamental principles

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Space Deterrence	◆ Space domain awareness ◆ Resilient space ◆ Satellite defense ◆ ASAT weapons (reversible, nonreversible, kinetic, non-kinetic)	◆ Great power competition ◆ Global proliferation of space actors and space systems	◆ Develop a comprehensive attribution strategy to strengthen adversary perception of U.S. ability to attribute attacks ◆ Consider how to communicate directly or indirectly to potential adversaries the resilience of U.S. space capabilities
A Roadmap for Assessing Space Weapons	◆ Smallsats, lasers, and high-power microwaves ◆ Faster/cheaper launch ◆ Proliferated LEO constellations ◆ Vulnerability of space-based systems ◆ Space domain awareness	◆ Great power competition ◆ Norms and behavior leadership ◆ Managing regulatory frameworks	Further research in: ◆ Effects of Chinese and Russian ASAT capabilities on the merits of U.S. space weapons ◆ Whether space-based weapons are protected by right of unrestricted overflight ◆ Strategy if Russia or China deploy space-to-Earth weapons first ◆ Effects of gray zone activities on space weaponization
The Arctic: Space-based Solutions	◆ Space-enabled Arctic communication, navigation, and observation ◆ Hybrid networks, enterprise cloud solutions ◆ Seamless data and connectivity	◆ Great power competition ◆ Expanding commercial capabilities and investment ◆ Collaborating with international partners ◆ Environmental conservation and management.	◆ Open, available, and shared systems for multi-partner operation ◆ Integrate evolving Arctic Strategy with U.S. allies ◆ Engage and incentivize commercial sector

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Challenges and Opportunities for NASA's Artemis Program	◆ Improved propulsion systems ◆ Inflatable entry, descent, and landing system ◆ Next generation spacesuit ◆ Lunar landers / lunar surface transport systems ◆ Reliable power ◆ Laser communications ◆ In-situ resource utilization ◆ Lunar Gateway	◆ Expanding commercial capability and investment ◆ Managing regulatory frameworks ◆ Collaborating with international partners ◆ Environmental conservation and management ◆ Norms and behavior leadership	◆ Rethink acquisition strategy for Mars missions ◆ Consider policies to improve transitions between programs and missions ◆ Apply lessons learned from Apollo to Artemis ◆ Explore opportunities for international and private sector involvement, particularly in LEO
Emerging Issues in New Space Services	◆ On-orbit inspection and maintenance ◆ Active debris removal ◆ Non-Earth imaging ◆ Planetary protection ◆ Spaceflight safety ◆ Commercial RF collection	◆ Expanding commercial capability and investment ◆ Managing regulatory frameworks ◆ Environmental conservation and management ◆ Global proliferation of space actors and space systems	◆ Seek technically informed and enabling regulation ◆ Develop guidelines and best practices ◆ Encourage the use of commercial capabilities as a service to government missions; ◆ Fund critical R&D
Human Spaceflight Safety	◆ Launch/spaceflight reliability ◆ Fast-paced suborbital flights ◆ Long-distance transportation (point to point) ◆ Moon and Mars travel	◆ Expanding commercial capability and investment ◆ Global proliferation of space actors and space systems ◆ Managing regulatory frameworks	◆ Update mishap investigation requirements ◆ Implement performance-based regulations when appropriate ◆ Establish a space safety institute

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Defense Space Partnerships	◆ Networked SSA ◆ Hosted payloads ◆ Systems integration/interoperability ◆ Combined space operations with international allies and partners ◆ Combined space systems acquisition	◆ Collaborating with international partners ◆ Great power competition ◆ Norms and behavior leadership ◆ Global proliferation of space actors and space systems	◆ Prioritize defense space international partnerships ◆ Lower space system classification levels and international ally and partner information releasability ◆ Involve international allies and partners in exercises and wargames ◆ Increase foreign liaison and exchange officer opportunities ◆ Develop common norms of behavior
Space-Based Solar Power	◆ Wireless power transmission ◆ Solar cell efficiency ◆ Cheaper launch (large satellites needed) ◆ Modular spacecraft components ◆ Space robotics for very large projects/ constellations	◆ Future markets and new space services ◆ Environmental conservation and management ◆ Expanding commercial capability and investment	◆ Decide whether to independently pursue, internationally collaborate, or pass on this technology ◆ Opportunity to establish U.S. leadership through R&D investment ◆ Could develop sustained and coordinated program leading to large-scale demonstration ◆ Adopt a portfolio management approach to encourage complete vision, efficient resource management and collaboration with partners
Space Game-Changers	◆ Breakthrough ◆ Disruptive ◆ Incremental ◆ Game changers	◆ Future markets and new space services ◆ Expanding commercial capability and investment ◆ Global proliferation of space actors and space systems	The national security space enterprise should institutionalize an innovation portfolio management framework to achieve enterprise goals and better resource and risk management—coverage across disruptive, breakthrough, and incremental technologies, applications, and business models

Managing the Growth of Space Traffic

The first section of this report covered issues related to managing the growth of space traffic and orbital debris as well as the related issues of airspace integration and light pollution. Many of these challenges lend themselves to a strategic foresight approach due to the complexity and interaction of different actors and technologies. The problem of space debris is particularly relevant to the strategic foresight framework. Because behavior by any one actor in space can affect everyone and because hazards such as orbital debris accumulate over time, many decisions will need to be made in the near-term horizon to navigate toward the preferred outcomes in the long run. Although there may not be significant immediate incentives to mitigate or remove space debris, the actions taken (or not taken) now could have serious consequences for the space environment in the future. Questions raised by the two key uncertainties that will affect the path toward the future include "What actors and organizations will have the most interest and capability in shaping norms, laws, and best practices in debris management?" and "In what ways will commercial actors exacerbate or mitigate space traffic and orbital debris?"

Uncertainty in what kinds of actors will be pursuing what kinds of behaviors in space means uncertainty in how best to approach developing norms, regulations, and best practices that will be most effective at managing space traffic. There are many possibilities in the degree to which commercial actors will affect space traffic in the future and whether those effects will be positive (such as through innovative technologies or mechanisms of debris mitigation or removal) or negative (such as through increased risk of collisions through the exponential expansion of constellations). As always, there is a spectrum of possible futures with any combination of these factors.

When looking to manage uncertainty and mitigate potential disruptors in the field of space traffic management, decisionmakers will need to ask themselves several key questions in order to determine a path forward:

- What incentives and disincentives can be provided to shape international behavior toward our preferred future?
- How do we develop patterns of cooperation between actors involved in activities related to space traffic management?
- How can decisions made by the U.S. government now affect which actors play the most important role in space traffic management in the future?

Applying the methodology of strategic foresight to these questions while scanning the horizon for indicators of what is to come can help form strategies for how to proceed.

National Security Space

The next category, national security space, features such issues as military organizations and doctrines, space weaponization, space deterrence, and synergies with other domains and the Arctic. As with the challenge of managing the growth of space traffic, applying strategic foresight to national security space will require consideration of timeliness and unity of approach. When scanning the horizon on this issue, the two key uncertainties raise questions such as "How will increased commercial activities and capabilities affect the relationship between military space and civilian contractors?" and "How will changes in the shape and form of alliances and adversaries affect how the military approaches collaboration, competition, and communication on national security issues?"

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The web of interconnected relationships and authorities between military, intelligence, civil, commercial, and policymaking organizations with a stake in national security space means that the preferred future for national security space and the actions taken to pursue it will need to be considered and coordinated across government and beyond. Furthermore, the long lead times on programs and systems development and inertia involved in some national security trends indicate that actions will need to be taken very soon, during the next presidential term, in order to influence these trends before the window of opportunity closes. For example, with the creation of the Space Force as the first new military service in over 70 years, it stands to reason that organizational and doctrinal decisions guiding the force could now shape its culture and capabilities for decades to come. That means that the fundamental decisions guiding the Space Force will not only have to keep in mind the current operational environment, but also the possible uncertainties and changes that will shape the space domain 20, 50, or 100 years into the future.

Therefore, several questions should be asked of national security space policymakers now in order to anticipate inflection points and calculate what actions can help navigate the uncertainties:

- How can we gain experience and insight into international space security actors now to prepare for future conflicts and disruptions?
- What kinds of flexibility, adaptability, and assurance can be built into formal processes like contracting and acquisitions or organizational structures themselves?
- How might the culture around innovation and risk-taking need to change to ensure we stay ahead?
- How can U.S. national security organizations posture themselves to effectively influence the security environment and anticipate how other actors might respond?

National security decisionmakers have always had to contend with uncertainty, but applying the methodologies and asking the questions raised by strategic foresight can make uncertainty an enabler for security instead of an obstacle.

Exploration and Economic Development

Apart from national security, exploration and economic development are two of the biggest topics that come to mind when thinking of the future of space. Just like space traffic management and national security space, activities in exploration and economic development such as NASA programs, new space services, human spaceflight, and workforce development will be dramatically affected by the progression of the two critical uncertainties. How will the balance between innovation and regulation shift over time, and how will that challenge affect which countries and industries become competitive and which fall behind? How will the changing actors and degree of influence of the commercial sector determine which aspects of space exploration and development are valued and pursued?

The public perception of the value of space, through taxpayers, investors, workers, and innovators will play a major role in which projects are pursued and, on a more fundamental level, how much attention and funding space activities will get as a whole. In times of economic, social, and political disruption and uncertainty, it is difficult to predict how space will be compared to other pressing issues. It is important to recognize, however, that activities in space are not a one-way street, and exploration and development in space can also have significant impact on capabilities and activities on Earth even though these effects can sometimes take many years to develop.

Policymakers will therefore find insight by examining responses to several questions:

- How can we anticipate and influence the perception of value in space activities?
- How can we work with stakeholders now to see what kinds of regulations will incentivize sustainable behaviors without disincentivizing operating in the United States?
- What pursuits in exploration and development have the greatest potential to affect life on Earth, whether tangibly or intangibly?
- How do we create a sustainable, thriving ecosystem that enables freedom and prosperous presence of humans in space?

Shaping the Future

The final category of chapters in *Space Agenda 2021* captures a diverse range of topics, all of which take approaches similar to the strategic foresight framework discussed in this chapter by emphasizing strategies to navigate potential disruptors. These disruptors could be technological (like space-based solar power) or political (like the diverse array of international space actors). Disruptors could even come in the form of new business processes or markets, as described in the "Space Game Changers" chapter. While no one set of trends could unify or encapsulate the themes discussed in these chapters, they serve as representations of how tools from the strategic foresight collection can be used to scan the horizon and plan to navigate disruption before it happens.

Again, the answers will not come easily and some may be impossible to fully grasp while dealing with uncertainty. The future is not set or predetermined for any of these issues, but many actions taken in the near future will have irrevocable effects on the direction in which we move. Therefore, asking the right questions and looking for these potential inflection points become the first steps in a process of scanning the horizon, developing insight, and taking action to move incrementally toward the preferred future.

Conclusion

The space enterprise has witnessed significant evolution and upheaval in recent years with the authorization of the U.S. Space Force and other organizational changes, proliferation of ever-larger and more capable constellations in low Earth orbit (LEO), and the progress of the Artemis Program toward a manned return to the moon. The COVID-19 pandemic has served as a sobering reminder of how surprise and uncertainty can disrupt the space enterprise from all angles. The pandemic has placed limitations on how the space workforce builds systems, shares information, and conducts business. It has revealed vulnerabilities in government agencies, large contractors, and small startups alike as crucial meetings have been canceled, supply chains have been interrupted, and businesses of all sizes have faced financial disaster. In many cases, the people and programs of the space enterprise have demonstrated incredible resiliency in the face of such disruption, but resiliency alone will not ensure the health of the enterprise against future crises. Applying tools such as strategic foresight can help policymakers holistically manage complexity or catastrophe; foresight can improve future preparedness and shape our nation's vision for achieving our preferred future for the space enterprise *today*.

At this crucial turning point, we should consider how incorporating anticipatory thinking might look at a national level, thinking through our vision across multiple futures and laying out a roadmap for how we will get there. Several futures for the space enterprise could develop following the COVID-19 pandemic, including a return to business as usual, the slashing of budgets and programs amid economic crises, or the strategic adaptation of programs and process allowing the United States to outpace its adversaries in space.[3] Once we identify, clarify, and align around preferred futures, we can also identify the push and pull factors that will help or hinder pursuit of that set of goals and the potential strategic levers that the United States can employ. This could include factors such as the recovery or failure of small businesses or the relative

intensity with which adversaries pursue their own space programs despite the economic effects of the pandemic. The key is to be strong on vision and flexible on approach. The United States needs to know where it wants to go, but it must be ready to adapt and respond to obstacles on the road to get there.

Whichever future we arrive at, it is fast approaching. Decisions made in 2021 will determine where we go next, and the stakes are high. With the clarity of vision and flexibility of approach enabled by strategic foresight practices, today's decisionmakers can determine tomorrow's success for the nation's leadership in space, even in the face of uncertainty.

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