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Research Paper

The Future of Space Commercialization

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Executive Summary

This paper argues for the importance of commercial uses of outer space to the economy and national security of the United States. It lays out a short history of developments in commercial outer space, enumerates the challenges facing this emerging market, and offers suggestions for policies to address these challenges. It's not possible to provide comprehensive answers to all of the problems the United States may encounter in outer space, but the suggestions provided offer a starting point for creating a healthy, safe, and robust commercial space environment.

Commercial outer space can promote economic growth, innovation, and stronger national security. However, achieving these goals will require several changes in space policy:

- The Office of Commercial Space Transportation (FAA AST) should be elevated to a separate bureau under the Department of Transportation;
- Responsibility for situational awareness of non-national-security-related space assets should be placed in a non-profit, non-governmental, multi-stakeholder organization;
- When the government requires space capabilities, it should buy privately-provided services and encourage competition in launch and non-launch markets; and
- Government agencies with regulatory or oversight authority over the commercial space industry should default to approval for new missions. Agency procedures for overruling default approval should be transparent and should include a process of appeal.

The United States is on the cusp of having an independent commercial space market. With a few smart decisions and a policy of regulatory restraint, the government can simultaneously promote innovation, growth, and national security, while proving that enterprise in space does not require the backing of a large nation state. That would be a giant leap for mankind.

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Introduction

The launch of Sputnik in 1957 marked mankind's first foray outside the atmosphere of the planet it calls home. For the decades that followed, the main actors in space were nation-states. Large spacefaring countries built the vehicles that took people and cargo into orbit and to the moon, crafted international space law, and shaped the main investments in space technology.

In the early decades of space use, commercial access to space was primarily communications,[1] with limited remote imaging starting in the 1990s.[2] This started to change in the early 2000s with a combination of events. New commercial actors began to enter the space arena, looking to disrupt both space launch services and use space in new exotic ways. The U.S. government also moved its purposeful degradation of the Global Positioning System (GPS) signal to non-governmental devices.[3] This decision opened navigational and timing data across industries,[4] and eventually paved the way for personal navigation.[5]

Other countries have also ramped up their use of space. Of global government space expenditures in 2014, non-U.S. spending increased to 46 percent.[6] Internationally, the commercial sector grew to 76 percent of total space market share.[7] Outer space is no longer a playground reserved only for nation states. Despite the many benefits of this change, it also results in a host of new concerns. More actors in space means growing complexity and more potential for collisions or disagreements over orbital assignments. U.S. national security rests on access to its own communications, navigation, and reconnaissance space systems. Other countries look to expand their own security by using outer space, expanding potential conflict into orbit. International law about outer space is ambiguous at best, and domestic U.S. law has a range of organizational and regulatory complexities.

American space policy, and the private industry attached to it, rests on a delicate balance between foreign policy, domestic regulation, and technological development. The pressures on this balance have increased in recent years and the United States will have to revisit how it approaches outer space. The growing crowdedness, increasing number of spacefaring nations, and new uses of outer space are all burdens that the U.S. regulatory and security apparatus is not currently designed to handle. The growth of private launch services and commercial satellites is starting to strain the regulatory system that manages them. This strain, and the rise of new uses of outer space, have

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[1] Whalen, David J., "Communications Satellites: Making the Global Village Possible," NASA, Nov. 30, 2010, http://history.nasa.gov/satcomhistory.html.
[2] DigitalGlobe, "Commercial Remote Sensing: An Historical Chronology," April 9, 2010, http://lasp.colorado.edu/~bakerd/files/Uzzle_Remote_Sensing_04_06_2010.pdf.
[3] GPS.gov, "Selective Availability," Sept. 23, 2016, http://www.gps.gov/systems/gps/modernization/sa/.
[4] United States Department of Commerce, "U.S. Secretary of Commerce Wiliam M. Daley Applauds Decision to make Global Positioning System More Accurate for Civilian Users," May 1, 2000, http://www.gps.gov/systems/gps/modernization/sa/daley/.
[5] Fleishman, Glenn, "How the iPhone knows where you are," Macworld, April 28, 2011, http://www.macworld.com/article/1159528/smartphones/how-iphone-location-works.html.
[6] The Space Foundation, "The Space Report: 2015," 2015, https://www.spacefoundation.org/sites/default/files/downloads/The_Space_Report_2015_Overview_TOC_Exhibits.pdf.
[7] Ibid.

revitalized debates over what role the U.S. government should, or should not, play in overseeing commercial actors in outer space.

This paper will attempt to lay out the importance of commercial outer space, both to the United States' economy and its national security. It will also provide a short history of developments in commercial outer space, the challenges this emergent market faces, and some steps the United States could take moving forward. While it is beyond the scope of this paper to provide comprehensive answers to all of the problems the United States may encounter in outer space, the suggestions provided will hopefully be a starting point to creating a healthy, safe, and robust commercial space environment. Commercial outer space, if promoted properly, can induce economic growth, innovation, and stronger domestic security. This will require changes to how the government is organized to manage outer space (including where it places regulatory authority and how it handles space situational awareness), how it handles its own space business, and how regulators engage with space-based enterprises.

Part I: The Importance of Space

Outer space is relatively removed from daily life, yet it is more important than many expect. If one could drive upwards at 60 miles per hour, it would take less than one and a half hours to get to space.[8] Very few Americans, however, consider how space intersects with their lives on a constant basis. There are three areas in which it does so: (1) the economy; (2) innovation; and (3) national security.

The Space Economy

The size of the space economy is far larger than many may think. In 2015 alone, the global market amounted to $323 billion.[9] Commercial infrastructure and systems accounted for 76 percent of that total,[10] with satellite television the largest subsection at $95 billion.[11] The global space launch market's share of that total came in at $6 billion dollars.[12] It can be hard to disaggregate how space benefits particular national economies, but in 2009 (the last available report), the Federal Aviation Administration (FAA) estimated that commercial space transportation and enabled industries generated $208.3 billion in economic activity in the United States alone.[13] Space is not just about satellite television and global transportation; while not commercial, GPS satellites also underpin

[8] Glastonbury, Matt, "If you could drive a car upwards at 60mph, how long would it take to get to the moon?" *Science Focus,* Sept. 5, 2015, http://www.sciencefocus.com/qa/if-you-could-drive-car-upwards-60mph-how-long-would-it-take-get-moon.
[9] The Space Foundation, "The Space Report: 2016," 2016, http://www.spacefoundation.org/sites/default/files/downloads/The_Space_Report_2016_OVERVIEW.pdf.
[10] Ibid.
[11] FAA, "The Annual Compendium of Commercial Space Transportation: 2016," Jan., 2016, https://www.faa.gov/about/office_org/headquarters_offices/ast/media/2016_Compendium.pdf.
[12] Ibid.
[13] FAA, "The Economic Impact of Commercial Space Transportation on the U.S. economy in 2009," Sept., 2010, https://www.faa.gov/news/updates/media/Economic%20Impact%20Study%20September%202010_20101026_PS.pdf.

personal navigation, such as smartphone GPS use, and timing data used for Internet coordination.[14] Without that data, there could be problems for a range of Internet and cloud-based services.[15]

There is also room for growth. The FAA has noted that while the commercial launch sector has not grown dramatically in the last decade, there are indications that there is latent demand.[16] This demand may catalyze an increase in launches and growth of the wider space economy in the next decade. The Satellite Industry Association's 2015 report highlighted that their section of the space economy outgrew both the American and global economies.[17] The FAA anticipates that growth to continue, with expectations that small payload launch will be a particular industry driver.[18]

In the future, emerging space industries may contribute even more the American economy. Space tourism and resource recovery—e.g., mining on planets, moons , and asteroids—in particular may become large parts of that industry. Of course, their viability rests on a range of factors, including costs, future regulation, international problems, and assumptions about technological development. However, there is increasing optimism in these areas of economic production. But the space economy is not just about what happens in orbit, or how that alters life on the ground. The growth of this economy can also contribute to new innovations across all walks of life.

Technological Innovation

Innovation is generally hard to predict; some new technologies seem to come out of nowhere and others only take off when paired with a new application. It is difficult to predict the future, but it is reasonable to expect that a growing space economy would open opportunities for technological and organizational innovation.

In terms of technology, the difficult environment of outer space helps incentivize progress along the margins. Because each object launched into orbit costs a significant amount of money—at the moment between $27,000 and $43,000 per pound, though that will likely drop in the future[19]—each reduction in payload size saves money or means more can be launched. At the same time, the ability to fit more capability into a smaller satellite opens outer space to actors that previously were priced out of the market. This is one of the reasons why small, affordable satellites are increasingly pursued

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[14] Jewell, Don, "The Internet of Everything: it's All in the Timing," *GPS World*, June 20, 2015, http://gpsworld.com/the-internet-of-everything-its-all-in-the-timing/.

[15] Hollingham, Richard, "What would happen if all satellites stopped working?" *BBC Future*, June 10, 2013, http://www.bbc.com/future/story/20130609-the-day-without-satellites.

[16] The FAA notes that, "several new launch vehicles are being developed specifically to address what some believe is latent demand among small satellite operators." (The Federal Aviation Administration, "The Annual Compendium of Commercial Space Transportation: 2016," Jan. 2016, https://www.faa.gov/about/office_org/headquarters_offices/ast/media/2016_Compendium.pdf.)

[17] The Satellite Industry Association, "2016 State of the Satellite Industry Report," Sept. 2016, http://www.sia.org/wp-content/uploads/2016/09/SSIR16-2016-09-23-Update.compressed.pdf.

[18] The Federal Aviation Administration, "The Annual Compendium of Commercial Space Transportation: 2016," Jan., 2016, https://www.faa.gov/about/office_org/headquarters_offices/ast/media/2016_Compendium.pdf.

[19] Kramer; Mosher, "Here's how much money it actually costs to launch stuff into space," *Business Insider*, Jul. 20, 2016, http://www.businessinsider.com/spacex-rocket-cargo-price-by-weight-2016-6/#does-this-sound-ridiculously-expensive-10.

by companies or organizations that cannot afford to launch larger traditional satellites.[20] These small satellites also provide non-traditional launchers, such as engineering students or prototypers, the opportunity to learn about satellite production and test new technologies before working on a full-sized satellite. That expansion of developers, experimenters, and testers cannot but help increase innovation opportunities.

Technological developments from outer space have been applied to terrestrial life since the earliest days of space exploration. The National Aeronautics and Space Administration (NASA) maintains a website that lists technologies that have spun off from such research projects.[21] Lightweight nanotubes, useful in protecting astronauts during space exploration, are now being tested for applications in emergency response gear and electrical insulation. The need for certainty about the resiliency of materials used in space led to the development of an analytics tool useful across a range of industries. Temper foam, the material used in memory-foam pillows, was developed for NASA for seat covers. As more companies pursue their own space goals, more innovations will likely come from the commercial sector.

Outer space is not just a catalyst for technological development. Satellite constellations and their unique line-of-sight vantage point can provide new perspectives to old industries. Deploying satellites into low-Earth orbit, as Facebook wants to do,[22] can connect large, previously-unreached swathes of humanity to the Internet. Remote sensing technology could change how whole industries operate, such as crop monitoring, herd management, crisis response, and land evaluation,[23] among others. While satellites cannot provide all essential information for some of these industries, they can fill in some useful gaps and work as part of a wider system of tools. Space infrastructure, in helping to change how people connect and perceive Earth, could help spark innovations on the ground as well. These innovations, changes to global networks, and new opportunities could lead to wider economic growth.

National Security

Perhaps the most important legacy application of outer space for Americans is national security. The United States relies heavily on satellites for capabilities that make its global power projections and deterrence structures work. Satellites provide valuable real-time intelligence information, connect platforms and bases around the world, and provide the basis for highly accurate navigational systems on land, at sea, and in the air.

It is not just that this space infrastructure is useful for American warfighters, but that it is essential. Elbridge Colby, a senior fellow at the Center for a New American Security (CNAS), wrote in his examination of recent changes to the space environment that space capabilities are “the stuff of

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[20] Batencourt, Mark, “Rise of the CubeSats,” *Air & Space Smithsonian*, Jan. 20, 2016, http://www.airspacemag.com/space/rise-cubesats-180957827/?no-ist.
[21] NASA, “NASA Spinoff 2016,” *INSIDE 2016,* https://spinoff.nasa.gov/Spinoff2016/toc_2016.html.
[22] Dzonzi, Prinsloo, “Facebook is Launching Rural Internet Access Via Satellite for Africa,” *Bloomberg*, Aug. 31, 2016, http://www.bloomberg.com/news/articles/2016-08-31/facebook-to-start-africa-satellite-this-week-to-find-rural-users.
[23] U.S. Committee on Science and Technology, “Remote Sensing Data: Applications and Benefits,” April 7, 2008, https://www.gpo.gov/fdsys/pkg/CHRG-110hhrg41573/html/CHRG-110hhrg41573.htm.

which American global military primacy is made."[24] Military capabilities that the United States has come to rely on, from remotely piloted drones to precision weaponry, all rely on satellites.[25] To manage this, The United States Space Command has 38,000 airmen based around the world working to secure access to national security space assets.[26]

It is not just the military that relies on satellites—the intelligence community does too. While the unclassified military space budget is around $10 billion on outer space a year,[27] total national security space spending may be over $25 billion annually.[28] This reliance on outer space is not going to end any time soon. At an event at the Center for Strategic and International Studies (CSIS) on October 24, 2016, Deputy Assistant Secretary of Defense for Space Policy Doug Loverro, spoke to the importance of leveraging space capabilities.[29] Mr. Loverro highlighted that space is fundamental to everything the United States does in conventional war, as well as nuclear deterrence, and disabused the notion that the country should pursue ways of fighting and projecting power without relying on outer space. Such an argument, he contends, is "not an attractive notion." Going to war without space capabilities would put American soldiers at risk.

Even so, managing the space environment is becoming more complex for the defense community. There is a growing perception that heavy reliance on satellites creates a soft spot in American defenses.[30] America's rivals have highlighted U.S. space capabilities as a possible vulnerability to exploit.[31] For some capabilities—particularly situational awareness, nuclear command and control, and coordination among America's widespread military and intelligence assets—satellites have become an almost "single point of failure."[32] This means that any one accident or disruption could degrade or shut down a key tool. Concerns over this reliance have led to warnings of a "space Pearl Harbor"[33] as defense analysts see American outer space assets as potentially ripe targets for exploitation by international rivals.[34]

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[24] Colby, Elbridge, "From Sanctuary to Battlefield: A Framework for a U.S. Defense and Deterrence Strategy in Space," *Center for a New American Security*, Jan. 2016, https://s3.amazonaws.com/files.cnas.org/documents/CNAS-Space-Report_16107.pdf.
[25] Martin, David, "The Battle Above," *60 Minutes, CBS*, April 26, 2015, http://www.cbsnews.com/news/rare-look-at-space-command-satellite-defense-60-minutes/.
[26] Ibid.
[27] The Space Foundation, "U.S. Defense Space-Based and -Related Systems: Fiscal Year 2015 Budget Comparison," 2015. http://www.spacefoundation.org/sites/default/files/downloads/Update%206%20FY%202015%20DoD%20Space%20Budget%20Comparison.pdf.
[28] The amount of actual spending is not publically available, given classified spending - Martin, David, "The Battle Above," *60 Minutes, CBS*, April 26, 2015, http://www.cbsnews.com/news/rare-look-at-space-command-satellite-defense-60-minutes/.
[29] CSIS, "The U.S. Military and Commercial Space Industry," Oct. 24, 2016, https://www.csis.org/events/us-military-and-commercial-space-industry.
[30] Billings, Lee, "War in Space May be Closer Than Ever," *Scientific American,* Aug. 20, 2015, https://www.scientificamerican.com/article/war-in-space-may-be-closer-than-ever/.
[31] Colby, Elbridge, "From Sanctuary to Battlefield ... ," *Center for a New American Security*, Jan. 2016, https://s3.amazonaws.com/files.cnas.org/documents/CNAS-Space-Report_16107.pdf.
[32] Clark, Colin, "Space Command Readies for War with 'Space Enterprise Vision," *BreakingDefense,* June 20, 2016, http://breakingdefense.com/2016/06/space-command-readies-for-war-with-space-enterprise-vision/.
[33] Broder, Jonathan, "Why the Next Pearl Harbor could happen in Space," *Newsweek*, May 4, 2016, http://www.newsweek.com/2016/05/13/china-us-space-wars-455284.html.
[34] Clark, Colin, "Space Command Readies for War with 'Space Enterprise Vision."

The United States is moving to mitigate some of these concerns by making more resilient and adding redundancy to the system. That way, if one satellite is damaged or degraded, the system as a whole still functions.

The success or failure of these efforts may ultimately depend on commercial outer space. Building up U.S. space capabilities solely through government initiative could have both fiscal and operational problems—such a strategy would likely be expensive and spread unforeseen vulnerabilities across the entire American satellite fleet.

Working with commercial companies for capabilities can reduce costs while providing strength through variation.[35] Commercial satellites, for example, currently provide the military with 80 percent of its satellite communications needs.[36] Commercial providers also provide the vital launch services that get the satellites into orbit. Today, these providers are the United Launch Alliance (ULA)[37] and Space Exploration Technologies (SpaceX).[38] Without these companies, the United States government would have to rebuild national launch capabilities. In the future, other commercial launch companies, such as Orbital ATK[39] and Blue Origin,[40] could also provide launch services for the military and intelligence community. In short, a more robust commercial space market is key to ensuring the resilience of American national security by assuring access to space.

Part II: A Brief History of Commercial Use of Outer Space

The roots of the human enterprise in space trace back to competition between the Soviet Union and the United States. The concern that the geopolitical rivalry and nuclear arms race between the two superpowers would extend into outer space culminated in the 1967 Outer Space Treaty (OST).[41] It attempted to smooth over concerns between the United States and the Soviet Union about the other placing nuclear weapons in space. Wider issues were also addressed. Each country would respect the other's space vehicles and astronauts, neither would claim sovereignty over celestial bodies, and neither would station weapons of mass destruction in space. Most importantly for the commercial use of outer space, each would assume responsibility for the actions of their private individuals and companies in outer space. Since 1967, 91 countries have signed the OST—including all of the current major spacefaring nations.[42]

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[35] CSIS, "The U.S. Military and Commercial Space Industry."
[36] Lober, Rick, "Why the Military Needs Commercial Satellite Technology," *Defense One*, Sept. 25, 2013, http://www.defenseone.com/technology/2013/09/why-military-needs-commercial-satellite-technology/70836/.
[37] While a commercial company, ULA was originally created as the sole-source launch provider for the military. United Launch Alliance, http://www.ulalaunch.com/.
[38] Space Exploration Technologies, http://www.spacex.com/.
[39] Orbital ATK, https://www.orbitalatk.com/.
[40] Blue Origin, https://www.blueorigin.com/.
[41] Official title: The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies.
[42] U.S. Department of State, "The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies," *Bureau of Arms Control, Verification, and Compliance*, Jan. 27, 1967, http://www.state.gov/t/isn/5181.htm#signatory.

American interest in the commercial use of outer space can be traced back to the National Aeronautics and Space Act of 1958.[43] In it Congress declared that it was to the benefit of the United States for the concurrently established National Aeronautics and Space Administration (NASA) to "seek and encourage, to the maximum extent possible, the fullest commercial use of space."[44] Subsequent presidential administrations have maintained this policy.

Under President Johnson, the expectation that non-state actors would operate in space was reflected in the OST.[45] President Carter, in his National Space Policy of 1978, reasserted that the United States would encourage domestic use of outer space both for "economic benefit" and the "technological position of the United States."[46] The Reagan Administration dramatically shifted domestic consideration of commercial space policy, at least as it applied to National Space Policy.

At first, President Reagan's National Space Policy of 1982 carried over language similar to that used by President Carter.[47] By 1988, however, President Reagan's second National Space Policy had elevated commercial space to the same significance as civil and national security space.[48] Commercial space was addressed in more detail, with the word "commercial"appearing 68 times in the document.[49] The policy directed the government to purchase commercial capabilities, avoid crowding out private investment where possible, and take as light an approach to commercial space regulation as possible.

President H.W. Bush not only maintained the Reagan Administration's policies,[50] but specified in greater detail how the government should promote commercial space.[51] Additionally, the first Bush administration's space policy included commercial launch needs into overall launch strategy.[52] The Clinton Administration expanded space policy further, advocating for government use of commercial space products and services "to the fullest extent possible."[53] Additionally, the Clinton Administration highlighted "free and fair trade" in commercial space launch as an American goal.[54] Under President George W. Bush, the U.S. government's attention shifted away from space after the terrorist attacks of September 11, 2001. The 2006 National Space Policy took a similar view to commercial outer space

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[43] Air University, "National Space Policy," *United States Air Force,* http://www.au.af.mil/au/awc/awcgate/au-18/au180046.htm.
[44] NASA, *National Aeronautics and Space Act of 1958, as amended,* Aug. 25, 2008, p. 4., http://history.nasa.gov/spaceact-legishistory.pdf.
[45] NASA, *The Outer Space Treaty of 1967*, Oct. 26, 2006, http://history.nasa.gov/1967treaty.html.
[46] The White House, *Presidential Directive/NSC-37*, Jimmy Carter Presidential Library, May 11, 1978, https://www.jimmycarterlibrary.gov/documents/pddirectives/pd37.pdf.
[47] The White House, *National Security Decision Directive 42,* NASA Historical Reference Collection, July 4, 1982, https://www.hq.nasa.gov/office/pao/History/nsdd-42.html.
[48] Air University, "National Space Policy," *United States Air Force,* http://www.au.af.mil/au/awc/awcgate/au-18/au180046.htm.
[49] The White House, *Presidential Directive on National Space Policy,* NASA Historical Reference Collection, Feb. 11, 1988, https://www.hq.nasa.gov/office/pao/History/policy88.html.
[50] The White House, *National Space Policy Directives and Executive Charter*, Air University, Nov. 2, 1989, http://www.au.af.mil/au/awc/awcgate/nspd1.htm.
[51] The White House, *U.S. Commercial Space Policy Guidelines - NSPD-3*, Air University, Feb. 11, 1991, http://www.au.af.mil/au/awc/awcgate/nspd3.htm.
[52] The White House, *National Space Launch Strategy - NSPD-4*, Air University, July 10, 1991, http://www.au.af.mil/au/awc/awcgate/nspd4.htm.
[53] The White House National Science and Technology Council, "Fact Sheet: National Space Policy," Sept. 19, 1996, http://history.nasa.gov/appf2.pdf.
[54] Ibid.

as the previous administrations.[55] However, the post-1999 placement of all space technologies under the International Traffic in Arms Regulation (ITAR) munition list started taking a toll on the industry.[56]

Under President Obama, national use and reliance on commercial space products and services had also been a major focus of the National Space Policy.[57] In particular, the Obama Administration pursued increased use of commercial launch services, including low-earth orbit satellite launches and resupply missions to the International Space Station (ISS).[58] This long focus on promoting commercial outer space throughout successive administrations has been a major catalyst for the dynamic commercial space industry that exists in the United States. The Obama Administration also reviewed the export control regime for space, and with Congressional support, shifted some satellites and related technologies from the stricter ITAR munitions list to the looser Export Administration Regulations (EAR) list in 2014.[59]

The commercial sector was an early player in the use of space, at least in terms of communications satellites. In 1960, AT&T filed an application with the Federal Communications Commission (FCC) for an experimental satellite—before the United States even had policies in place to manage such a request.[60] The private sector was, even then, pushing the boundaries of innovation in space. Domestically, the U.S. government retained a monopoly on access to space for years. Between the 1960s and the 1980s, anything launched into orbit—including commercial satellites—had to travel on the government's launch vehicles.

In 1984, the United States passed the Commercial Space Launch Act (CSLA).[61] The law gave the Department of Transportation (DOT) the authority to regulate commercial space launch activities—although it did not grant authority to regulate movements in orbit or beyond.[62] The CSLA opened up the ability for American companies to launch satellites on launch vehicles not completely controlled by the government.[63] It took a while for a private company to send a payload into space, however. In fact, the first commercial launcher in the Western world was created when a private company, Arianespace, took over operations of the European Space Agency's Ariane launch vehicle.[64]

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[55] The Office of Science and Technology Policy, *U.S. National Space Policy*, NASA Historical Reference Collection, Sept. 14, 1996, http://history.nasa.gov/ostp_space_policy06.pdf.
[56] Zelnio, Ryan, "The effects of export control on the space industry," *The Space Review*, Jan. 16, 2006, http://www.thespacereview.com/article/533/1.
[57] The White House, *National Space Policy of the United States of America*, NASA Historical Reference Collection, June 28, 2010, http://history.nasa.gov/national_space_policy_6-28-10.pdf.
[58] The White House, *National Space Transportation Policy*, NASA Historical Reference Collection, Nov. 21, 2013, http://history.nasa.gov/nstp11-21-13.pdf.
[59] Bureau of Industry and Security, "Export Control Reform: Spacecraft/Satellites," *Department of Commerce*, 2014, https://www.bis.doc.gov/index.php/forms-documents/pdfs/1008-satellites-final-rules/file.
[60] Whalen, David, "Communications Satellites: Making the Global Village Possible," NASA, Nov. 30, 2010, http://history.nasa.gov/satcomhistory.html.
[61] Authorities now under *U.S.C. 51, Chapter 509*, http://uscode.house.gov/view.xhtml?path=/prelim@title51/subtitle5/chapter509&edition=prelim.
[62] SpacePolicyOnline, "Space Law," http://www.spacepolicyonline.com/space-law.
[63] The first commercial space launch entity was actually established in Europe in 1980 - Arianespace, "Milestones," http://www.arianespace.com/company-milestones/.
[64] FAA, "Origins of the Commercial Space Industry," https://www.faa.gov/about/history/milestones/media/Commercial_Space_Industry.pdf.

In the United States, interest in commercial launch companies picked up when it became clear that the Space Shuttle would not be able to maintain a schedule rigorous enough to cover commercial launch demands.[65] After the *Challenger* explosion, President Reagan issued an order banning commercial payloads on the Shuttles.[66] Private consumers turned to expendable launch vehicles for reliable services. The first American-licensed commercial launch occurred in 1989 when Space Services, Inc. sent a payload into orbit on a Starfire rocket.[67] Commercial launch development had begun, but remained focused on communications and imaging for the next decade.

This started to change at the turn of the century, however. Prior to May 2000, non-governmental access to the GPS was purposefully degraded.[68] That degradation had limited the beneficial uses of GPS for the commercial sector, restricting accuracy to 100 meter radii. With those restrictions lifted, commercial use of GPS expanded across a range of industries.[69] This decision would eventually lead to the ability of individuals to rely on GPS for personal navigation.[70]

The new millennium also saw a growing number of commercial actors interested in more exotic uses of outer space. In 2000, Amazon founder Jeff Bezos created a company with the aim of getting tourists into suborbital space.[71] The company—Blue Origin—was the first to land a reusable rocket booster in 2015. It has since repeated the feat several times. In 2002, PayPal tycoon Elon Musk founded SpaceX, which became the first private company to return a spacecraft from low-earth orbit to Earth.[72] SpaceX has since won contracts with NASA to run supply trips to the ISS and has landed a reusable booster system several times. Richard Branson founded Virgin Galactic to pursue space tourism in 2004, and cofounded The Spaceship Company in 2005 to produce the spacecraft for that tourism.[73] His companies are working with the engineer that won the Ansari X Prize (announced in 1996)[74] to turn that reusable suborbital vehicle into a viable space tourism platform.[75] Bigelow Aerospace, founded in 1999, has focused on building habitats that can be more easily deployed to outer space or other celestial bodies. It launched prototypes in 2006 and 2007,[76] and currently has a test capsule attached to the ISS.[77] Other companies wanting to extract celestial resources, like Planetary Resources, are eyeing potential paydays from asteroids.[78] Most recently, Moon Express—a

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[65] Ibid.
[66] NASA, *Commercial Orbital Transportation Services: A New Era In Spaceflight*, NASA, Feb., 2014, https://www.nasa.gov/sites/default/files/files/SP-2014-617.pdf.
[67] FAA, "Origins of the Commercial Space Industry."
[68] GPS.gov, "Selective Availability," Sept. 23, 2016, http://www.gps.gov/systems/gps/modernization/sa/.
[69] United States Department of Commerce, "U.S. Secretary of Commerce Wiliam M. Daley ...," May 1, 2000, http://www.gps.gov/systems/gps/modernization/sa/daley/.
[70] Control over the space and ground segments remained under government control, though there were proposals to privatize them as well.
[71] Malik, Tariq, "Jeff Bezos' Blue Origin Launches and Lands Private Rocket for Third Time," *Space.com*, April 2, 2016, http://www.space.com/32453-blue-origin-launches-and-lands-rocket-third-time.html.
[72] Space Exploration Technologies, http://www.spacex.com/about.
[73] The Spaceship Company, http://thespaceshipcompany.com/.
[74] The Ansari X Prize awarded $10 million to the first group to privately launch a manned system to 100km above Earth's surface twice within two weeks. http://ansari.xprize.org/.
[75] Howell, Elizabeth, "Virgin Galactic: Richard Branson's Space Tourism Company," *Space.com*, Feb. 17, 2016, http://www.space.com/18993-virgin-galactic.html.
[76] Bigelow Aerospace: https://bigelowaerospace.com/.
[77] Wall, Mike, "Astronauts Enter Inflatable Space Station Module for 1st Time," *Space.com*, June 6, 2016, http://www.space.com/33087-astronauts-enter-inflatable-space-station-habitat.html.
[78] Planetary Resources: http://www.planetaryresources.com/.

company with the goal of mining lunar resources—received a positive payload review from the FAA to send the first private rover to the Moon.[79]

There are also more traditional aerospace companies (that have other portfolios) that have won contracts to ferry cargo to the ISS, including Orbital ATK and the Sierra Nevada Corporation. The growth of the commercial space market has been impressive. The Space Foundation's 2016 report found that the overall space economy had reached $323 billion in 2015.[80] The commercial space industry, and the infrastructure supporting it, accounted for 76 percent of the space economy.

Today, the commercial component of the space economy encompasses everything from satellite communications, broadcasting, and remote imaging to the terrestrial infrastructure and workforce that supports those satellites.[81] From OneWeb to SpaceX, more and more companies are looking to deploy their own satellite systems to provide direct Internet connections around the world.[82] With innovations and technological progress in remote imaging, companies like Planet Labs are marketing satellite Earth observations to a diverse array of markets, from agriculture to energy production.[83] Human rights groups are using remote imaging to document war crimes,[84] gaining data in hours for much lower costs and risk than dispatching on-the-ground teams. The economic benefits from space also come when companies and people can hook into government satellite constellations. National navigation systems, such as the GPS constellation, provide highly accurate timing data for billions of Internet users and millions of systems[85]—data that if unavailable would cause potential problems for the Internet and cloud-based computing services.[86]

Part III: Challenges Ahead

The growth of the space market has sparked growing interest in regulation. With private companies wanting to launch thousands of new satellites, the U.S. government is looking at how best to undertake space traffic management.[87] Certain parts of the potential space economy, such as mining resources from asteroids, raise concerns about possible clashes between American ambition and

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[79] Wall, Mike, "Moon Express Approved for Private Lunar Landing in 2017, a Space First." *Space.com*, Aug. 3, 2016, http://www.space.com/33632-moon-express-private-lunar-landing-approval.html.
[80] The Space Foundation, "The Space Report: 2016," 2016, http://www.spacefoundation.org/sites/default/files/downloads/The_Space_Report_2016_OVERVIEW.pdf.
[81] Ibid.
[82] Patterson, Thom, "Google, Facebook, SpaceX, OneWeb plan to beam Internet everywhere," *CNN*, Nov. 9, 2015, http://www.cnn.com/2015/10/30/tech/pioneers-google-facebook-spacex-oneweb-satellite-drone-balloon-internet/.
[83] Planet Labs: https://www.planet.com/markets/.
[84] Friedman, Uri, "What War Crimes Look Like from Space," *The Atlantic,* Feb. 11, 2015, http://www.theatlantic.com/international/archive/2015/02/satellites-human-rights-space-nigeria/385063/.
[85] Jewell, Don, "The Internet of Everything: it's All in the Timing," *GPS World*, June 20, 2015, http://gpsworld.com/the-internet-of-everything-its-all-in-the-timing/.
[86] GPS data is used for the timestamps on packets of data transferred between computers. Inaccuracies in these timestamps mean slower Internet and inability to transfer data. Accuracy of location would be degraded with the loss of GPS, which could cause major transportation issues. Location-based services for mobile users would also be disrupted. *See generally* Hollingham, Richard, "What would happen if all satellites stopped working," *BBC,* June 20, 2013, http://www.bbc.com/future/story/20130609-the-day-without-satellites.
[87] Gruss, Mike, "Washington Weighs an FAA Role in Managing Space Traffic," *Space News*, Dec. 3, 2015, http://spacenews.com/might-the-faa-inherit-the-space-traffic-management-role/.

international law.[88] The Moon-bound Moon Express rover in particular has given rise to questions about which government agency (if any) should have regulatory authority over such missions and what the best approach to such authorities would be. Private industry also lacks certainty on a range of possible missions, with no clear indication as to what will be permitted.

The answers to these questions are complex, tying together a range of challenges facing the use and exploration of outer space. Some of these challenges are technical, while some are environmental. Some of these challenges are created by current regulatory approaches, and some may be created in the future by new regulations. Commercial outer space also ties into wider national security and international relations concerns. Any policies that deal with outer space have to take into account these varying, and sometimes contradictory, pressures on the commercial space market.

The recent success of the commercial space market comes not with a lack of challenges, but in spite of them. These challenges can be divided under the following general sections: (1) a technically difficult space environment, (2) regulatory burdens, (3) national security ramifications, and (4) international disagreements.

Technical

Accessing outer space is technically challenging and can be dangerous. The Space Shuttle program, designed to provide reusable and routine access to space,[89] suffered the loss of two shuttles out of five—a 40 percent vehicular failure rate.[90] Granted, those accidents occurred over the shuttle's entire 30-year lifespan, but the loss of 14 people onboard those shuttles still outnumbers all casualties from all other global space launch systems combined.[91]

The commercial sector has seen its fair share of accidents as well. In 2014, the breakup of Virgin Galactic's SpaceShipTwo killed the copilot and injured the pilot.[92] In June 2015, one of SpaceX's Falcon Rockets exploded during launch, destroying the cargo meant for the ISS.[93] SpaceX had another rocket explode on September 1, 2016, during a routine test-fire,[94] destroying a satellite bought by Facebook to provide Internet to parts of Africa.

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[88] Davalos, Juan, "International Standards in Regualting Space Travel: Clarifying Ambiguities in the Commercial Era of Outer Space," *Emory International Law Review*, 2016, http://law.emory.edu/eilr/content/volume-30/issue-4/comments/standards-regulating-space-travel-ambiguities-outer-space.html.

[89] Siceloff, Steven, "Shuttle Fleet Left Mark in Space, Hearts," *NASA*, Feb. 1, 2015, https://www.nasa.gov/mission_pages/shuttle/flyout/shuttleachievements.html.

[90] Pinchefsky, Carol, "5 horrifying facts you didn't know about the space shuttle," *Forbes*, April 18, 2012, http://www.forbes.com/sites/carolpinchefsky/2012/04/18/5-horrifying-facts-you-didnt-know-about-the-space-shuttle/#28a3acc067b9.

[91] A launch pad test killed three astronauts in an Apollo I mission, and Russian space missions have had four total deaths. There have, as yet, been no reported Chinese taikonaut deaths.

[92] National Transportation Safety Board, "Commercial Space Launch Accident - SpaceShipTwo," July 28, 2015, http://www.ntsb.gov/news/events/Pages/2015_spaceship2_BMG.aspx.

[93] Wall, Mike, "SpaceX Rocket Explosion Likely Caused by Faulty Strut, Elon Musk Says," *Space.com*, July 20, 2015, http://www.space.com/29994-spacex-rocket-explosion-cause-faulty-strut.html.

[94] Calandrelli, Emily, "Here's what we know about the SpaceX explosion," *Techcrunch*, Sept. 1, 2016, https://techcrunch.com/2016/09/01/here-what-we-know-about-the-spacex-explosion/.

Launching rockets is clearly difficult. Reusing boosters for launch systems, as some companies have begun to do, is even more technically challenging. Both Blue Origin[95] and SpaceX[96] have demonstrated the capability to land their boosters after launch and intend to use these boosters to cut down on the overall costs of launches. Neither company has used a landed booster to launch governmental or commercial cargo, though they are getting closer to doing so. Blue Origin has used its rocket multiple times in a variety of tests,[97] and SpaceX has inked a contract to launch a commercial satellite with one of its previously used boosters.[98] Reusing a rocket comes with risks; and until reusable systems can be repeatedly demonstrated to be safe, customers and regulators may remain wary.[99] Newer, more complex systems may also see higher insurance rates; space insurers are already warning that they expect rates to increase.[100] Commercial concerns aside, launching government payloads or astronauts may require even more stringent checks if concerns over reusable rockets remain.

Of course, once in space, things do not get easier. The space environment is intensely challenging, with everything from dust to radiation being a potential issue. For companies wanting to move beyond orbit—for reasons that range from asteroid mining to exploration missions—problems will run the spectrum from the known to the unpredictable. As commercial companies expand outwards, they'll have to deal with expected problems like radiation and fuel generation, as well as whatever unanticipated issues may arise. For the companies focused on in-orbit capabilities, the most pressing technical problem will be debris.

Space Debris

Space debris is an increasingly problematic technical issue. As the number of state and private actors launching satellites increases, the amount of debris in orbit—defunct satellites, booster parts, bits of metal and scrap—also increases. In 2013, NASA reported that there were over 500,000 trackable pieces of space debris in orbit.[101] The problem has become worse since then and will continue to pose a real threat to spacecraft.

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[95] Malik, Tariq, "Blue Origin Aces 4th Reusable Rocket Launch (and Landing) in Live Webcast," *Space.com*, June 19, 2016, http://www.space.com/33214-blue-origin-lands-reusable-rocket-4th-time-webcast.html.

[96] Wall, Mike, "No. 5! SpaceX Lands Another Rocket During Space Station Cargo Launch," *Space.com* July 18, 2016, http://www.space.com/33443-spacex-dragon-launch-rocket-landing.html.

[97] Smith, Rich, "When Will SpaceX Catch Up to Blue Origin in Rocket Reusability?" *The Motley Fool,* June 11, 2016, http://www.fool.com/investing/2016/06/11/when-will-spacex-catch-up-to-blue-origin-in-rocket.aspx.

[98] De Selding, Peter, "SpaceX to launch SES-10 on previously flown Falcon 9 this year," *SpaceNews*, Aug. 30, 2016, http://spacenews.com/spacex-to-launch-ses-10-satellite-on-reused-falcon-9-by-years-end/.

[99] These concerns largely center on the condition of the rocket after each successive launch, given the high velocities and heat involved. *See generally* Masunaga, Samantha, "Rocket science? Check. But can SpaceX get through insurance hurdles?" *Los Angeles Times*, June 3, 2016, http://www.latimes.com/business/la-fi-spacex-insurers-20160603-snap-story.html.

[100] De Selding, Peter, "Space Insurers warn that current low rates are not sustainable," *SpaceNews*, Oct. 10, 2016, http://spacenews.com/space-insurers-warn-that-current-low-rates-are-not-sustainable/.

[101] Garcia, Mark, "Space Debris and Human Spacecraft," *NASA*, Sept. 26, 2013, http://www.nasa.gov/mission_pages/station/news/orbital_debris.html.

For example, the ISS has had to alter its orbit to avoid a potential collision.[102] In 2014, satellites were maneuvered over 120 times to reduce the risk of potential collisions with debris.[103] In 2009, there was a collision between two satellites—the first involving an operational satellite.[104] Space debris can be created quickly. Two events, the satellite collision in 2009 and the destruction of a satellite by China in 2007, created an estimated one-third of the actively-tracked debris in low-earth Orbit.[105]

To date, debris has not yet caused serious damage to space assets. However, this may not be the case in the future. The number of launches and satellites in orbit will grow significantly in the near future. There are currently around 1,500 operational satellites orbiting Earth,[106] and commercial space companies are looking to greatly expand this number. SpaceX submitted plans to the FCC for a constellation of 4,000 satellites to be deployed in the next five years.[107] Boeing applied to the FCC to deploy 1,396 satellites in the next six years.[108] These plans may not come to fruition, but it is clear that there is strong interest in expanding the number of satellites in orbit. This will increase the amount of debris, and the risk of collisions.

The debris issue may result in either regulatory steps taken to coordinate launches and reduce risks of accidental collisions or technological innovations to assist in "cleaning" the orbital environment. Either approach, however, will likely require delicate international negotiations and will require greater global cooperation than currently exists.

Current Regulations

Current American regulations focus on systems leaving or entering Earth's atmosphere and the capabilities of satellites in orbit. The current regulatory structure spans several government agencies, leading to a somewhat disjointed structure. While workable during an era of single-use outer space operations (placing satellites or space stations in orbit), it has become increasingly inadequate as more private actors enter the space economy and seek new opportunities.

To get a satellite in orbit, companies must go through the payload review process for launches and reentries.[109] This process is undertaken by the FAA's Office of Commercial Space Transportation (FAA AST), which has to sign off on a variety of checks before a launch can take place, including: flight termination system design testing, operating techniques, launch and reentry sites, and whether the

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[102] Ibid.
[103] Weedon, Brian, "Why Outer Space Matters: Brian Weedon on Natural and Human-Generated Threats on Satellites," Oct. 24, 2016, http://intercrossblog.icrc.org/blog/why-outer-space-matters-brian-weeden-on-natural-and-human-generated-threats-on-satellites.
[104] David, Leonard, "Effects of Worst Satellite Breakups in History Still Felt Today," *Space.com*, Jan. 28, 2013, http://www.space.com/19450-space-junk-worst-events-anniversaries.html.
[105] Ibid.
[106] Union of Concerned Scientists, "UCS Satellite Database," Aug. 11, 2016, http://www.ucsusa.org/nuclear-weapons/space-weapons/satellite-database#.V7HTwJMrKfc.
[107] De Selding, Peter, "SpaceX To Build 4,000 Broadband Satellites in Seattle," *SpaceNews*, Jan. 19, 2015, http://spacenews.com/spacex-opening-seattle-plant-to-build-4000-broadband-satellites/.
[108] Masunaga, Samantha, "Boeing applies for license to launch proposed satellite constellation," *Los Angeles Times*, June 23, 2016, http://www.latimes.com/business/la-fi-boeing-satellites-20160623-snap-story.html.
[109] Perlman, Benjamin, "Grounding U.S. Commercial Space Regulation in the Constitution," *Georgetown Law Journal*, 100 Geo. L.J. 929, March, 2012, p. 965.

launch complies with public health and safety considerations, international law and U.S. treaty obligations, and domestic national security interests.[110]

Depending on what the satellite does, it may run into regulations put in place by other agencies. Satellite use of the electromagnetic spectrum in outer space requires a license from the FCC to determine proper spectrum usage.[111] If the satellite is a private remote sensing system, it must be licensed through the National Oceanic and Atmospheric Administration (NOAA) within the Department of Commerce (DOC).[112] NOAA is tasked with making sure that any remote sensing done by private U.S. companies does not compromise national security or violate international obligations.[113]

The United States export control apparatus also controls what space technologies can be transferred to foreign countries or nationals. Because space technology can be used both for civil and military purposes, the United States does not want its capabilities falling into the wrong hands. Controlled technology is currently split between two lists separately maintained by the State Department (the International Traffic in Arms Regulations (ITAR)[114] and the DOC's Export Administration Regulations (EAR).[115] This system is complicated and can be difficult to navigate. Recent changes shifted some space technology from the stricter ITAR list to the looser EAR list, but ambiguities in the lists mean it can be difficult for companies to determine what approval they need.[116] Decisions made under the export regime can seem capricious, with similar parts controlled or not controlled depending on what industry they are produced for.[117] Because of the national security aspect of decisions, companies often never get a full explanation for decisions made.

Other than these main licensing areas, the rest of space has remained formally unregulated. The United States Air Force (USAF) keeps an eye on objects in orbit 10cm across or larger (though the commercial part of this "space traffic control" duty may be passed off to the DOT in the near future).[118] However, movement in orbit is not currently regulated, simply monitored. Outside of orbit, there are also no currently assigned agencies to provide regulation. Beyond launches, reentries, and some limits on capabilities and spectrum use, there is no regulation; nor is there a designated entity to produce potential regulatory proposals. There are national security decisions that play a role—such as restrictions on remote imaging quality, space situational awareness, and others—but these decisions

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[110] Federal Aviation Administration, "Licenses & Permits," https://www.faa.gov/about/office_org/headquarters_offices/ast/licenses_permits/.
[111] Federal Communications Commission, "Licensing," https://www.fcc.gov/licensing-databases/licensing.
[112] Ibid.
[113] National Oceanic and Atmospheric Administration, "About Commercial Remote Sensing Regulatory Affairs," http://www.nesdis.noaa.gov/CRSRA/index.html.
[114] U.S. Department of State, "The International Traffic in Arms Regulations (ITAR)," https://www.pmddtc.state.gov/regulations_laws/itar.html.
[115] Bureau of Industry and Security, "Export Administration Regulation Downloadable Files," https://www.bis.doc.gov/index.php/regulations/export-administration-regulations-ear.
[116] Foust, Jeff, "Despite Reforms, U.S. Export Control Rules Remain Complicated," *SpaceNews*, Nov. 1, 2014, http://spacenews.com/42430despite-reforms-us-export-control-rules-remain-complicated/.
[117] U.S. House of Representatives Small Business Committee, "Export Control Reform: Challenges for Small Business? (Part II)," *Hearing*, Feb. 11, 2016, https://www.youtube.com/watch?v=9uRZEXrmoss.
[118] Gruss, Mike, "Washington Weighs an FAA Role in Managing Space Traffic," *SpaceNews*, Dec. 3, 2015, http://spacenews.com/might-the-faa-inherit-the-space-traffic-management-role/.

are often up to the discretion of the official involved. However, more formal regulations may be on the way.

The current approach requires a launch licence for any commercial asset going into orbit. That means that there will be a *de facto* review of any mission beyond orbit. So far, a limited number of missions have been reviewed: Bigelow Aerospace module payloads (without a planned mission)[119] and the Moon Express rover mission. But Moon Express had to create a one-off application that worked its way through the Department of Defense, the State Department, NASA, NOAA, and the FCC for approval.[120]

The Moon Express application was successful and sets a precedent, but its *ad hoc* path to approval may not remain viable in the future. While commercial activities beyond orbit have been established as legal in the United States, the current process relies on opaque, discretionary decision-making within multiple agencies. It's difficult to trace such decisions back to individual officials, who have to consider national security and foreign policy decisions.[121] Without a formal process, firms have no way of knowing whether future missions will be permitted.[122] With so many agency stakeholders involved and an international obligation to authorize and supervise all private space missions, the U.S. government might lapse into *de facto* non-approval. It's easy to understand, then, why commercial space companies are concerned about regulatory uncertainty.[123] Industry concerns over the opacity and unpredictability of the mission approval process are likely to spur the government to consider new oversight mechanisms for the private exploration and use of outer space.

Future Areas of Regulation

In the medium- and long-run, new uses of outer space will place pressure on the U.S. government to craft new regulations. There may be some reforms to existing regulation—international development of remote imaging technology has reduced the United States' ability to demand limits on commercial remote sensing—but other areas will likely see regulations promulgated. Missions beyond Earth's orbit are one such area.

While the United States licenses and regulates launches, as well as in-orbit systems, it currently does not have a structure in place for beyond-orbit missions. Only one private company—Moon Express—has ever received permission to launch a mission beyond orbit, and it required a regulatory "patch" to get a positive payload review.[124] When more companies are able and willing to expand their presence beyond orbit, this patchwork system is unlikely to suffice. The government may have to

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[119] Foust, Jeff, "FAA Review a Small Step for Lunar Commercialization Efforts," *SpaceNews*, Feb. 6, 2015, http://spacenews.com/faa-review-a-small-step-for-lunar-commercialization-efforts/.
[120] Wall, Mike, "Moon Express Approved for Private Lunar Landing in 2017, a Space First," *Space.com*, Aug. 3, 2016, http://www.space.com/33632-moon-express-private-lunar-landing-approval.html.
[121] 51 USC Ch. 509: Commercial Space Launch Activites, http://uscode.house.gov/view.xhtml?path=/prelim@title51/subtitle5/chapter509&edition=prelim.
[122] Hampson, Joshua, "One Small Step Back to the Moon," *RealClearPolicy*, Aug. 24, 2016, http://www.realclearpolicy.com/articles/2016/08/24/one_small_step_back_to_the_moon_1699.html.
[123] Foust, Jeff, "Commercial Space Stations Face Economic and Regulatory Challenges," *SpaceNews*, Sept. 24, 2016, http://spacenews.com/commercial-space-stations-face-economic-and-regulatory-challenges/.
[124] Grush, Loren, "US government poised to approve first private mission to the Moon," *The Verge*, Aug. 2, 2016, http://www.theverge.com/2016/8/2/12275980/moon-express-private-mission-spaceflight-us-government.

create a transparent framework for approving licenses, or else open itself to possible accusations of favoritism.

At the moment, missions beyond Earth's orbit—to the moon or Mars, for example—are unmanned. Manned missions introduce another dynamic. Current regulation allows "informed consent" for spaceflight participants. This means that private companies can focus on regulations around launch systems and have passengers use waivers to acknowledge the risks. But this informed consent system currently only lasts until 2025.[125] Until then, the FAA is limited in the passenger regulations it can enact on the space industry.

Regulations on human travel, both in-orbit and beyond, will soon be an area of interest. If space tourism takes off, some types of space travel may become more similar to common carriers, such as atmospheric planes and ships, than experimental missions. If there are enough space tourism trips passing overhead, the U.S. government may be pushed to shift to a more hands-on regulatory approach.

There are parts of the space industry that are pushing for making the informed consent approach permanent.[126] They argue that there are several justifications for such a move, including: (1) the current system is working and fostering innovation; (2) the manned space market is still in early stages, and so needs protection from draconian regulation; (3) the manned space market is not monolithic, with newer systems like use of high-altitude balloons that are less mature than rockets or space planes; and (4) there are pronounced differences between in-orbit and beyond-orbit travel.[127]

At the same time, the pace of regulation will likely be attached to the pace of viable manned space travel. The next decade may see technological breakthroughs that greatly reduce costs. Companies like Bigelow Aerospace are working to create destinations for travelers into orbit and beyond.[128] It may not be that far in the future before regulators take a more heavy-handed approach to manned spaceflight. That approach will need to balance safety and innovation, and understand the nuances separating mature and developing technologies, as well as the different types of travel.

Space mining is another area of increasing interest for lawmakers and regulators. The 2015 U.S. Commercial Space Launch Competitiveness Act (CSLC) included language directed at facilitating commercial recovery of space resources by American citizens.[129] Plans to retrieve resources from space have their skeptics and proponents,[130] but there are those that seem intent on making space

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[125] United States Commercial Space Launch Competitiveness Act of 2015, https://www.congress.gov/114/plaws/publ90/PLAW-114publ90.pdf.

[126] MacCallum, Taber, " Opinion | Building a bright regulatory future for the commercial space industry," *SpaceNews*, Aug. 3, 2016, http://spacenews.com/building-a-bright-regulatory-future-for-the-commercial-space-industry/.

[127] Specifically, manned travel beyond orbit has increased risks from radiation. Any travel beyond orbit will have to deal with fuel issues, but will also be less crowded. *See generally* MacCallum, Taber, " Opinion | Building a bright regulatory future for the commercial space industry," *SpaceNews*, Aug. 3, 2016, http://spacenews.com/building-a-bright-regulatory-future-for-the-commercial-space-industry/.

[128] Bigelow Aerospac: https://bigelowaerospace.com/.

[129] United States Commercial Space Launch Competitive Act of 2015, https://www.congress.gov/114/plaws/publ90/PLAW-114publ90.pdf .

[130] David, Leonard, "Is Asteroid Mining Possible? Study Says Yes, for $2.6 Billion," *Space.com*, April 24, 2012, http://www.space.com/15405-asteroid-mining-feasibility-study.html.

mining a reality.[131] With the United States now recognizing citizens' rights to resources from asteroids or abiotic sources, once they have been obtained, it may appear that the regulatory issues are already handled. But that may not be the case. The 2015 Commercial Space Launch Competitiveness Act required a series of studies to look at American space activities and identify areas in which new authorities or licensing rules may be needed.[132] According to a letter from the Office of Science and Technology Policy to the Senate Committee on Commerce, Science, and Transportation and the House Committee on Science, Space, and Technology, "unprecedented commercial space activities" by American firms mean that the United States may not be fully in compliance with the Outer Space Treaty.[133] Due to this interpretation of the Outer Space Treaty, the Obama Administration began examining new mechanisms for oversight.

There is currently no established agency that would handle licensing for resource recovery missions. This may not be an issue for initial experimental missions, but the future may see strong competition between various private companies seeking the same sources of resources. There is also an issue of international law, and whether it compels the United States to be more specific about its regulation of private space companies. The OST makes nations responsible for space-based actions taken by its private citizens and companies.[134] If space mining becomes more viable, even if just to harness resources for use in space itself, there will likely be growing demand, domestically and internationally, for a coherent framework for claiming resources and interacting with other private actors. It may also be the case that current U.S. law suffices.

The international aspect of commercialization in outer space will be addressed more in depth later in this paper, but it does impact commercial space.[135] Companies looking to mine resources in space will likely pursue the easiest resources first, located on relatively close asteroids and possibly the moon. However, other countries could claim that American permission to its companies to own space resources violates the OST.[136] As the OST prevents claims of sovereignty—or national appropriation by any means—and nations are absolutely responsible for private companies' actions, other countries may be able to challenge the legitimacy of the CSLC.[137] At the same time, other countries are following the United States' lead and implementing national space mining laws,[138] arguing that recognizing property rights does not create an expansion of sovereignty into space. Luxembourg cites the

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[131] Planetary Resources: http://www.planetaryresources.com/.

[132] Office of Science and Technology Policy, "Reporting Requirement Contained in the U.S Commercial Space Launch Competitiveness Act," April 4, 2016, https://www.whitehouse.gov/sites/default/files/microsites/ostp/csla_report_4-4-16_final.pdf.

[133] Ibid.

[134] United Nations Office for Outer Space Affairs, *United Nations Treaties and Principles on Outer Space*, New York, 2002, http://www.unoosa.org/pdf/publications/STSPACE11E.pdf.

[135] Davies, Rob, "Asteroid mining could be space's new frontier: the problem is doing it legally," *The Guardian,* Feb. 6, 2016, https://www.theguardian.com/business/2016/feb/06/asteroid-mining-space-minerals-legal-issues.

[136] Davies, Rob, "Asteroid mining could be space's new frontier ...," *The Guardian,* Feb. 6, 2016, https://www.theguardian.com/business/2016/feb/06/asteroid-mining-space-minerals-legal-issues.

[137] The question at hand would be whether the awardance of property rights in space is merely a recognition of pre-existing rights, or undertaking a de facto expansion of sovereignty. That debate is beyond the scope of this paper, but the U.S. government may at least have an international incentive to *appear* to restrict space mining in the future, leading to a more hands-on regulatory approach.

[138] Jain, Rishabh, " Space Mining: Luxembourg's New Law To Give Private Companies Right To Outer Space Resources," *International Business Times*, Nov. 13, 2016, http://www.ibtimes.com/space-mining-luxembourgs-new-law-give-private-companies-right-outer-space-resources-2445432.

International Institute of Space Law in arguing that, "In view of the absence of a clear prohibition of the taking of resources in the Outer Space Treaty one can conclude that the use of space resources is permitted."[139] The OTS also left it up to individual nations to determine how to comply with its terms.[140] Of course, a significant determining factor in which interpretation wins out is to what extent states, particular major spacefaring nations, agree with either perspective.

While not new areas of regulation *per se*, laws surrounding orbital traffic, the use of the electromagnetic spectrum, and export controls may all see changes in the medium- to long-run as well. Satellite launching companies may come under more explicit regulations surrounding deorbiting practices and launch timings, given growing concerns over debris. Launches of cubesats—small, affordable satellites—may be catalytic drivers of these regulations, as their demand holds the potential to exponentially increase the number of satellites in orbit. Controls over the electromagnetic spectrum are likely to grow stricter as well, to ensure that this increase in satellites does not interfere with national security satellites or other private competitors. Export controls may be reduced as other countries catch up with American capabilities, but this is not guaranteed. A controversy in 1999 involving the transfer of American launch analysis technology to China led Congress to shift all satellite technology and related items away from EAR to ITAR—the stricter munitions list under the State Department.[141] While recent reform efforts have moved these technologies back to EAR,[142] a new controversy could see controls tightened again. Even with recent reforms, navigating the export control regime remains complicated and will likely remain a source of debate within both industry and government.[143] Significant technologies remain under ITAR.[144]

Of course, future U.S. regulations and laws surrounding space use and exploration will also be shaped by two large aspects of the space environment: national security considerations and international relations. Space has long since moved away from the bipolar Cold War dynamic to a much more complex multipolar system. The United States relies heavily on space assets for key military and intelligence capabilities, and other countries are quickly catching up. The interplay of national militaries, security regimes, and codes of conduct will play heavily into the future of commerce in outer space.

National Security

The importance of space capabilities to national security cannot be overstated. The U.S. military and intelligence community still exert large amounts of control and influence on outer space policy. There

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[139] Government of Luxembourg, "Did you know?" *Spaceresources.lu*, http://www.spaceresources.public.lu/en/did-you-know/index.html.
[140] Montgomery, Laura, "By the Outer Space Treaty's Own Terms, The U.S. Complies with Article VI of the Treaty," *Ground Based Space Matters, Law Offices of Laura Montgomery*, Dec. 17, 2016, http://groundbasedspacematters.com/index.php/2016/12/17/by-the-outer-space-treatys-own-terms-the-u-s-complies-with-article-vi-of-the-treaty/.
[141] Fishcer; Hutman, "U.S. Congress Authorizes Satellite Export Control Reform," *Pillsbury Law*, Dec. 21, 2012, http://www.pillsburylaw.com/publications/us-congress-authorizes-satellite-export-control-reform.
[142] Shane, John, "U.S. State and Commerce Departments Reform Export Controls Applicable to Satellites and Spacecraft Systems," *Wiley Rein LLP*, May 16, 2014, http://www.wileyrein.com/newsroom-articles-3161.html.
[143] Bureau of Industry and Security, "Export Control Reform Spacecraft/Satellites," July 28, 2014, https://www.bis.doc.gov/index.php/forms-documents/pdfs/1008-satellites-final-rules/file.
[144] Foust, Jeff, "Federal government tweaks space export control rules," *SpaceNews,* Jan. 12, 2017, http://spacenews.com/federal-government-tweaks-space-export-control-rules/.

are good reasons for this. The United States uses satellites for its nuclear command and control apparatus, military and intelligence surveillance, and national security communications and coordination.[145] Outer space is also becoming a more contested and dangerous national security environment.[146] For senior defense space experts, space is no longer perceived as a sanctuary.[147] If risks continue to propagate, the commercial outer space industry may see outer space become increasingly dangerous and controlled.

Defense of U.S. space systems is important, but the ability to do so will be complicated by space commercialization. There are several dynamics to space commercialization that will heighten national security concerns over outer space, including the number of actors involved in space, the growing crowdedness of outer space, and the increasing reliance on commercial providers for national security services. The first two issues tie into each other. The growing number of spacefaring countries and companies means that there are simply more satellites in orbit. From a defense perspective, this is a complication. To deter an attack on a satellite or degradation of systems capabilities, the United States needs to understand who the attacker is. In-orbit situational awareness is a must.

National satellites and equipment in orbit might be relatively easy to track, but if commercial companies flood Earth's orbit with thousands of new satellites, governmental tracking systems may not be able to adequately adjust. There is also the problem of determining whether a "private" satellite from another country is indeed privately-owned. In a world where soldiers have been disguised to prevent identification, a national satellite might be disguised as a commercial one.[148] Would the United States not be suspicious if a private Russian satellite caused a problem for an American national security satellite? For that matter, would Russia not be suspicious if a private American satellite caused problems for one of theirs? Additionally, private satellites might be hacked by non-state actors.[149] Attribution is an important issue, as the United States would be unable to respond to a problem without accurately identifying the responsible parties. Confusion over who is involved would slow response time, which would also degrade deterrence.[150] If American rivals can complicate attribution, they may take action that they would otherwise consider escalatory. By the time the United States assigns responsibility in this scenario, that rival might have been able to achieve a goal that would be difficult to roll back.

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[145] Stwarts, Phillip, "U.S. needs to defend space assets, Pentagon space expert says," *Air Force Times*, Jan. 29, 2016, https://www.airforcetimes.com/articles/us-needs-to-defend-space-assets-pentagon-space-expert-says.

[146] Billings, Lee, "War in Space May Be Closer Than Ever," *Scientific American*, Aug. 10, 2015, https://www.scientificamerican.com/article/war-in-space-may-be-closer-than-ever/.

[147] Marshall Jr., Tyrone, "Officials: Space no Longer a Sanctuary; Sequester a Threat," *DoD News, Defense Media Activity*, March 26, 2015, http://www.defense.gov/News/Article/Article/604366.

[148] Shevchenko, Vitaly, ""Little green men" or "Russian invaders"?" *BBC*, March 11, 2014, http://www.bbc.com/news/world-europe-26532154.

[149] Nakashima, Ellen, "Russian hacker group exploits satellites to steal data, hide tracks," *The Washington Post*, Sept. 9, 2015, https://www.washingtonpost.com/world/national-security/russian-hacker-group-exploits-satellites-to-steal-data-hide-tracks/2015/09/08/c59fa7cc-5657-11e5-b8c9-944725fcd3b9_story.html.

[150] Secure World Foundation; CSIS, "Space Deterrence Workshop Report," May 3, 2010, http://swfound.org/media/7176/space_deterrence_workshop_report_final.pdf.

This means that even with efforts to improve situational awareness,[151] commercial space companies may see growing restrictions on where satellites can be placed. The United States may wish to revisit ideas to restrict the number of objects close to its security satellites.[152] It may also restrict how close American non-governmental equipment can get to rival powers' sensitive satellites. It could be detrimental to international stability if a private U.S. satellite got too close to a Chinese or Russian spy satellite. Other countries may warn private companies away from certain orbital paths for the same reasons. Crowding in space is not yet an urgent issue, but it may be in the not so distant future. The interplay between commercial outer space and national security space will become harder to manage as more satellites begin populating orbital space.

Yet another issue is the U.S. government's increasing reliance on commercial space companies for national security services. Private companies have long been a part of outer space launches—ULA, for example—but the DOD is looking at possibly using commercial capabilities for satellite communications[153] and remote imaging.[154] There are also a growing number of private companies that have interests in space outside of government work. SpaceX wants to get to Mars. Bigelow Aerospace wants to build private and/or corporate space stations. Virgin Galactic wants to get tourists into space. Planetary Resources wants to mine asteroids for profit.

NASA and the U.S. military have contracts with some of these companies for launches.[155] In the future, however, the military and government agencies may be more heavily relying on commercial companies for launches, equipment, and services. If the commercial sector becomes a more influential part of the market than the government, as has happened in other areas of technological development, government priorities may take a lower priority to space companies than commercial priorities. In the long-run, this may have two effects: (1) commercial companies could become large enough to push back on policies they disagree with, similar to the Apple vs FBI encryption debate; and (2) as a result of this reliance, the U.S. government may shift from an open, innovation-fostering approach to space to a more controlled and regulated approach.

Complex national security issues could directly hinder commercial development of space. The national security apparatus in the United States, which can wield significant influence over the licensing process, may restrict actions in space to reduce some of these concerns. If conflict breaks out over space satellites and infrastructures, the actions the U.S. military may take could be purely based on military/intelligence strategy. This could directly damage commercial space assets, or indirectly make the space environment unviable for commercial launches or assets. It would be in the best interest of companies seeking to operate in outer space to pay close attention to the increasing tensions in outer space. Industry may be able to encourage de-escalatory action by the United States or avoid undertaking actions that may increase tensions themselves.

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[151] Wall, Mike, "US Air Force Launches 2 Military Surveillance Satellites," *Space.com*, Aug. 19, 2016, http://www.space.com/33800-air-force-surveillance-satellites-launch-afspc-6.html.
[152] Wohlstetter; Chow, *Self-Defense Zones in Space,* Pan Heurisitics, June 15, 1986, http://albertwohlstetter.com/writings/19860615-AW-Chow-SDZsInSpace.pdf.
[153] Gruss, Mike, "COMSATCOM Pathfinder funds withheld in Senate draft defense bill," *SpaceNews*, May 18, 2016, http://spacenews.com/comsatcom-pathfinder-funds-withheld-in-senates-draft-defense-bill/.
[154] Gruss, Mike, "Intelligence agencies announce new cooperation on commercial imagery," *SpaceNews,* July 17, 2016, http://spacenews.com/intelligence-agencies-announce-new-cooperation-on-commercial-imagery/.
[155] Gruss, Mike, "SpaceX wins $82 million contract for 2018 Falcon 9 launch of GPS 3 satellite," *SpaceNews*, April 27, 2016, http://spacenews.com/spacex-wins-82-million-contract-for-2018-falcon-9-launch-of-gps-3-satellite/.

International Relations

The international issues in space are not exclusively security-centric. There are also legal and economic problems at play in the commercialization of outer space. During the Cold War, the United States and the Soviet Union worked to pass the OST. The OST helped tamp down concerns that either superpower would begin claiming parts of the moon or other planets. The treaty itself was also a compromise between the two ideologies in play. The Soviet Union did not want private ownership to extend into space, while the United States wanted to eventually unleash capitalism into the cosmos.[156] However, the primary concern was over military expansion and the possible terrestrial ramifications, and a deal was struck. Private actors and companies could go into space, but their launching nation would be responsible for their actions.[157] Not only would nations be responsible for private actors in space, but action taken in space by non-governmental entities would require the "authorization and continuing supervision" of their country.[158] This was codified in Article VI of the treaty.

For decades, this compromise did not pose any major challenges to American space exploration. Since that exploration was undertaken under national auspices and with national intentions, it made sense that the U.S. government would be responsible for any actions taken in space. Now, however, the private-public connection may become problematic as private actors pursue activities in space that have no direct public connection.

For example, it is unclear how the United States would manage disagreements between an American company undertaking moon exploration and another nation's moon exploration missions. What happens if another country grants licensing rights to a private company to harvest resources on the same asteroid that an American company has received licenses to mine? If an American private satellite crashes into a Chinese or Russian satellite, will the U.S. government honor its responsibility for its commercial space entities? Will the other country demand that the United States honor its signing of the OST and place tighter restrictions on its commercial space industry?

While the OST bans sovereign declarations over parts of the moon and other celestial bodies, it also prohibits the interference with other nations' space equipment. As recently pointed out in *The Harvard Gazette* by senior astrophysicist Martin Elvis, this non-interference protocol could allow valuable parts of the moon to be "claimed" anyway by nations or companies.[159] How would spacefaring nations deal with allegations that their companies were "hogging" parts of the moon? The United States has also ratified the Convention on International Liability for Damage Caused by Space Objects.[160] Under this convention, the United States may be liable for actions taken by private companies in space, depending on proof of fault. This potential liability may also constrain what the U.S. government is willing to tolerate from commercial space actors.

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[156] Koerth-Baker, Maggie, "Who Makes the Rules for Outer Space?," *PBS: Nova Next*, Nov. 30, 2015, http://www.pbs.org/wgbh/nova/next/space/space-law/.
[157] United Nations Office on Space Activities, *United Nations Treaties and Principles on Outer Space*, New York, 2002, http://www.unoosa.org/pdf/publications/STSPACE11E.pdf.
[158] Ibid.
[159] Powell, Alvin, "Eternal light, up for grabs," *Harvard Gazette*, July 12, 2016, http://news.harvard.edu/gazette/story/2016/07/eternal-light-up-for-grabs/.
[160] United Nations Office on Outer Space Affairs, *Convention on International Liability for Damage Caused by Space Objects,* Sept. 1972, http://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introliability-convention.html.

This odd arrangement between allowing private action in space, but tying those actions back to a national accountability injects uncertainty into the international politics of outer space. Because countries ultimately "bear international responsibility … whether such activities are carried on by governmental agencies or by non-governmental entities,"[161] there is a national incentive to control this uncertainty with regulation. As the U.S. government is the ultimate underwriter for the American space industry, it will come under increasing pressure to dictate the activity of that industry. This becomes more likely as the national security tension over outer space increases.

American commercial space companies have benefited from two checks on this regulatory pressure. First, many of the longer-term ideas for commercial space operations have only recently become viable. Asteroid mining, or commercial trips to the Moon, were long considered science fiction dreams. But with Moon Express' regulatory permission to send a private mission to the moon[162] and proposals for asteroid mining no longer laughed out of investment meetings,[163] whole new areas of space exploration and commerce no longer seem unviable.

Second, the commercial space industry has long had one dominant customer: the U.S. government. Even today, SpaceX has focused on breaking into the markets to launch USAF satellites[164] and has a major customer in NASA.[165] In the future, however, this may not be the case. Elon Musk has long made it clear that his end goal is to establish a colony on Mars.[166] Planetary Resources wants to mine asteroids for its own reasons,[167] and Moon Express wants to explore the Moon for "commercial lunar exploration and discovery."[168]

For now, these two checks have meant that the U.S. government has created a relatively permissive regulatory structure. The CSLC[169] was passed to incentivize American companies to push faster and harder to get into space. But as these dynamics change—as commercial use of space is normalized and as companies increasingly strike out on their own—the United States may quickly move away from this permissive environment. International tension might drive the government to consider whether the benefits from outer space are worth the terrestrial headaches. Disagreements in space may force its regulatory hand.

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[161] Koerth-Baker, Maggie, "Who Makes the Rules for Outer Space," *PBS: Nova Next*, Nov. 20, 2015, http://www.pbs.org/wgbh/nova/next/space/space-law/.
[162] Hampson, Joshua, "One Small Step Back to the Moon," *RealClearPolicy,* Aug. 24, 2016, http://www.realclearpolicy.com/articles/2016/08/24/one_small_step_back_to_the_moon_1699.html.
[163] The Economist, "Space: A Sudden Light," *The Economist: Technology Quarterly*, Aug. 25, 2016, http://www.economist.com/technology-quarterly/2016-25-08/space-2016.
[164] Gruss, Mike, "SpaceX wins $82 million contract for 2018 Falcon 9 launch of GPS 3 satellite," *SpaceNews*, April 27, 2016, http://spacenews.com/spacex-wins-82-million-contract-for-2018-falcon-9-launch-of-gps-3-satellite/.
[165] De Selding, Peter, " SpaceX wins 5 new space station cargo missions in NASA contract estimated at $700 million," *SpaceNews*, Feb. 24, 2016, http://spacenews.com/spacex-wins-5-new-space-station-cargo-missions-in-nasa-contract-estimated-at-700-million/.
[166] Wall, Mike, "Now Is the Time to Colonize Mars, Elon Musk Says," *Space.com*, Dec. 16, 2015, http://www.space.com/31388-elon-musk-colonize-mars-now.html.
[167] Planetary Resources: http://www.planetaryresources.com/.
[168] Moon Express, *U.S. Government Approves Plans for Moon Express to Become First Private Company to Venture Beyond Earth's Orbit,* Aug. 3, 2016, http://www.moonexpress.com/files/moon-express-press-kit.pdf.
[169] United States Commercial Space Launch Competitiveness Act of 2015, https://www.congress.gov/114/plaws/publ90/PLAW-114publ90.pdf.

In light of this, the U.S. government may try to thread the needle while mitigating international concerns. When the United States passed the Space Resource and Utilization Act, it did not include licensing rules for space mining—possibly because it could have been seen as the United States running roughshod over international norms.[170] The reality is that the regulatory environment for commercial space companies will not be truly predictable until the viability of their actions is demonstrated. At that point, a variety of international and domestic pressures will begin to weigh on how the U.S. government considers space commerce and regulation.

In the Future

All of these challenges need to be taken into account as the future of commercial outer space is considered. It is beyond the scope of this paper to provide in-depth policy recommendations, but there are some forward-looking steps that can be taken. If done responsibility, these actions could help mitigate current problems for commercial outer space while also responsibly positioning the United States for success in the future.

Part IV: Policy Recommendations

The continued growth of commercial outer space will rest on how the government is organized to engage with it, how the government does its own space business, and how the government allows and promotes private business in space. To that end, the following policy recommendations can help guide policymakers and their staffs in promoting this still nascent and increasingly important industry.

Organizational

One of the main questions facing the future of space commercialization is how the government will be organized to manage the expected changes. Will the system remain fragmented across agencies, or will it be consolidated into one? Will non-national security space situational awareness leave the USAF? Should anything change at all? These questions are not just important in themselves, but because good or poor organizational structures will shape *how* future decisions are made. Regardless of what policies are pursued, there are two organizational changes that the United States could make to benefit commercial outer space.

Elevate the Office of Commercial Space Transportation

First, the importance of outer space has outgrown the current organizational approach. The FAA AST does not have the clout it should have within the federal government. When the CSLA was passed in 1984, the authority of the FAA AST was not within the FAA—it was within the Office of the Secretary of Transportation. That office was only folded into the FAA in the 1990s[171] Now, space has become important enough to merit its own bureau within the DOT.

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[170] Koerth-Baker, Maggie, "Who Makes the Rules for Outer Space," *PBS: Nova Next*, Nov. 20, 2015, http://www.pbs.org/wgbh/nova/next/space/space-law/.

[171] Simberg, Rand, "Keep the FAA's Head in the Clouds: Why the Agency Should Not Be Regulating Space," *The New Atlantis,* June 10, 2016, http://www.thenewatlantis.com/publications/keep-the-faas-head-in-the-clouds.

Making FAA AST a separate DOT bureau would give it a larger voice in the government and improve its budgetary position. The move would also separate its mission—licensing commercial space operations and launches—from the FAA's broader mission to police the safety of the national airspace. The FAA generally deals with the mature airline industry, and focuses on safety. Space transportation is not yet a mature industry, and so the government agency that manages has to strike a more delicate balance between public safety and industry growth and development. Unlike the rest of the FAA, the FAA AST has a legislative mandate to promote commercial space. Space is also not directly comparable to airspace, as it requires significant international interaction and orbital positions are not "owned" by any particular nation. A separate administrator of space transportation would allow that reality to be reflected and would separate negotiations from space from terrestrial airspace concerns.

Having a separate sub-cabinet level for space could also alleviate growing pressures on the FAA. With growing responsibilities in a range of areas, the FAA has faced challenges with the increases in its space portfolio. A report from the Government Accountability Office (GAO) released in June 2016 found that the growth of commercial space launches have increased inspections from an annual average of 90 between 2006-2014 to 216 in 2015.[172] The FAA is also facing increases in new types of vehicles and technologies, new launch sites for inspections, and managing non-federal or commercial launch sites. All of this increases possible exposure for government liability, given current indemnification laws that place risks on the government for certain catastrophic problems.[173] As commercial space operations ramp up, the office that calculates possible government exposure, works to protect public safety, undertakes inspections, and handles international engagement will be increasingly strained. Additionally, the FAA will increasingly have to readjust how it allocates funds between its aviation and space obligations. Given the scope and maturity of the aviation industry, space may not receive the attention required. Organizationally, it makes sense to give FAA AST office the budgetary importance, authority, and presence to more effectively manage commercial space operations. Promoting FAA AST's position would also mean a clearer oversight from Congress, given the approval mechanism it holds for officials at the sub-cabinet level.

This move would also help delineate decisions involving beyond-orbit missions. While the FAA was involved in the recent payload review process of the Moon Express rover mission to the Moon, there are questions about exactly what authority it possesses for non-launch/reentry private action in space.[174] The debate that the Moon Express mission sparked involves unanswered questions about both domestic and international legality. Launch and reentry authority within the FAA initially made sense, given the FAA's oversight of national airspace. That logic becomes more and more strained the further one gets from that national airspace. The process that Moon Express had to go through to get permission was reminiscent of the *original* reason for the creation of the OCST (before it became FAA AST). In 1981, Space Services Incorporated (SSI) sought approval to launch its suborbital booster.[175] It quickly became clear that there was no specific agency with the authority to approve the launch, and SSI had to get permission from the FAA, NASA, and the State Department among others. Over the

[172] Dillingham, Gerald, *Commercial Space: Industry Developments and FAA Challenges*, United States Government Accountability Office, June 22, 2016, http://www.gao.gov/assets/680/677943.pdf.
[173] Dillingham, Gerald, *Commercial Space: Industry Developments and FAA Challenges*, United States Government Accountability Office, June 22, 2016, http://www.gao.gov/assets/680/677943.pdf.
[174] Klotz, Irene, "Exclusive - The FAA: regulating business on the moon," *Reuters,* Feb. 3, 2015, http://www.reuters.com/article/us-usa-moon-business-idUSKBN0L715F20150203.
[175] Fairman; Apern; Carr; Dean; Seidman, "Organization and Management Analysis of the Office of Commercial Space Transportation," *National Academy of Public Administration*, 1992.

next three years, when other companies requested launch permission, a dozen federal agencies had become involved in the process.[176] The same complexities seem posed crop up again with beyond-orbit or in-orbit missions.

A separate Bureau of Commercial Space Transportation would then be freer, both in culture and mandate, to promote commercial space missions in orbit and beyond. While the elevation itself would not determine *what* policies the United States would then pursue, the office itself could be shaped to more readily serve as a contact point for industry. At the moment, industry has to keep track of multiple FAA offices' policy positions. For example, the Air Traffic Organization (ATO) in the FAA has its own commercial space integration approaches.[177] These multiple offices do not always agree on policy approaches. Of course, commercial space launches need to coordinate with the wider national air space. Public comments and debate about how to approach that integration can be beneficial. But it should be clear to companies which government entity to turn to for a final ruling on policy. This would result in greater regulatory and legal certainty for space startups and the burgeoning commercial launch industry. The FAA AST and wider FAA already operate under different acts, so separating them would not require a complete legislative rework.

This change would not solve all of the organizational problems that exist within the United States' governance of commercial outer space. Commercial outer space rests on policies made across the government, not just the DOT. How the interagency process is managed will need review in its own right, particularly its transparency over *why* decisions have been made restricting commercial activities in space. While strengthening the promotion of commercial space launch is only one step in this process, it is an important step.[178] Any action in space first rests on getting into space. Strengthening the government entity tasked with promoting that access is necessary.

Space Situational Awareness

The United States needs to resolve its current commercial space situational awareness (SSA) problem. The USAF is currently managing national SSA, but may pass off the non-national security part of that task while continuing to focus specifically on military space assets.[179] The FAA has been highlighted as the possible agency in which to house commercial, civil, and foreign SSA—and has indicated that it is willing to take on that mission.[180] However, the same reasons that support elevating FAA AST out of the FAA are relevant in the SSA issue.

The FAA makes the argument that it is best positioned to handle the international aspect of SAA[181] —informing other countries of possible in-orbit collisions and managing global safety discussions—but outer space is an unusual nexus of national security, government activity, private commerce, and common heritage. The main spacefaring nations all rely heavily on space, or are ramping up space

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[176] Ibid.
[177] Davis, Bill, "ATO Commercial Space Integration," Space Traffic Management Conference: Emerging Dynamics, *Embry-Riddle Aeronautical University*, Nov. 18, 2016, http://commons.erau.edu/stm/2016/friday/6/.
[178] [redacted], "Commercial Space Industry Launches a New Phase," *Congressional Research Service,* Dec. 12, 2016, https://www.everycrsreport.com/files/20161212_R44708_a35133df2d936afd171d81bb13f6f60f4a89821f.pdf.
[179] Werner, Debra, "Congress gets report on giving FAA space traffic role," *SpaceNews*, Sept. 21, 2016, http://spacenews.com/congress-gets-report-on-giving-faa-space-traffic-role/.
[180] Ibid.
[181] Ibid.

infrastructure, for defense and intelligence operations. Countries without current space operations expressed concerns that the capability gap they face will increasingly widen, particularly if the main spacefaring nations lock in enviable orbits. This may make a FAA-styled approach increasingly difficult in the future. Even an elevated FAA AST may not be perceived as sensitive enough to other nations.

Situational awareness—though *not* orbit assignments, direct regulation, or licensing—might be best undertaken by a multi-stakeholder non-profit entity. A transition to such an entity would take longer than spinning off non-military SSA to the FAA, but would have several important advantages.

A non-profit, non-governmental entity, in separating the authority to license launches and that of monitoring civil, foreign, and commercial satellites, would be less open to accusations of American domineering in space. While the United States would still control its own operations in space, cooperation on SSA would be a symbolic outreach to other spacefaring nations. That could potentially open the number of countries, organizations, universities, and private groups willing to be involved in its SSA mission. As the mission of this private entity would be to simply warn nations and companies of possible collisions, it would not interfere with national or corporate interests in terms of launches. A non-profit, non-governmental SSA entity is not unprecedented. The Space Data Association pools data from participating commercial satellite operators.[182] However, for such an effort to be viable it needs buy-in from the U.S. government.

There are costs to such a system. The defense community would maintain its own catalog for protecting national security assets, and at least some of the data in such a non-government entity would come from civil agencies. Public funding would have to play a part. This duplication, however, may have lower costs than a civil agency like the FAA running the whole show. Non-governmental groups, such as research groups or companies, would have incentives to pick up some of the costs. Because current SSA capabilities rest on DOD investments, updates and new systems have been delayed lately.[183] Participation in a non-profit, non-governmental entity would allow companies speed that process by directly funding new tools and equipment. A recent Institute for Defense Analyses report found that non-governmental entities are already providing SSA services and may even surpass government capabilities for conjunction analysis in the near future.[184]

There are also concerns about such a system from the national security world. A non-defense SSA catalog—either in a civil agency or a non-government agency—could limit America's ability to protect sensitive missions and assets in space. While these concerns are legitimate, the reality is that the trend is moving away from secrecy in space. Actors outside the United States, such as the Space Data Association, are already working towards private space situational awareness.[185] Hobbyists can already track national security assets.[186] The situation is similar to what happened with encryption in

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[182] Space Data Association, "SDA Overview," http://www.space-data.org/sda/about/sda-overview/.
[183] Lal; Picard; Weedon, "Approaches to Civil Space Situational Awareness (SSA)," *FAA Industry Day*, Oct. 25, 2016, https://www.faa.gov/about/office_org/headquarters_offices/ast/media/STPI_SSA_Industry_Briefing.pdf.
[184] Nightengale; Lal; Weedon; Picard; Eisenstadt, *Evaluating Options for Civil Space Situational Awareness (SSA)*, *Institute for Defense Analyses: Science & Technology Policy Institute*, August 2016, https://www.ida.org/idamedia/Corporate/Files/Publications/STPIPubs/2016/P-8038.ashx.
[185] Weedon, Brian, "Time for the U.S. military to let go of □the civil space situational awareness mission," *SpaceNews Magazine*, September 12, 2016, http://www.spacenewsmag.com/commentary/time-for-the-u-s-military-to-let-go-of-%E2%80%A8the-civil-space-situational-awareness-mission/.
[186] Ibid.

the 1990s, and the United States faces either exporting private SSA capabilities to the rest of the world, or having an active role in how it takes shape.

On the other hand, there are national security benefits for promoting a non-governmental space situational awareness organization. The USAF would offload some of its costs. With better access to data, and increased engagement, the commercial sector would be better positioned to avoid problems in space. Commercial space entities involved with SSA may also be able to provide quicker updates to SSA capabilities. The USAF has already acknowledged that SSA can be done by non-state actors, recently awarding a contract to Applied Defense Solutions specifically to work towards a commercial augmentation of defense SSA.[187]

This movement of responsibility would allow the USAF to focus on monitoring and protecting American national security assets, becoming more focused in its situational awareness duties. The DOT—ideally via an elevated FAA AST—could focus on promoting commercial outer space and licensing missions. The non-profit, private SSA entity, free of international claims of bias or U.S. government control, but likely with a high number of American stakeholders, could focus purely on the best practices for distributing information on orbits and movements in space. Coordination would of course occur between the three sectors of the space environment, but the simplified missions would increase the likely of success for each and remove potential conflicts of interest.

How Government Does Space Business

The United States will also have to take a new look at how it does business. The U.S. government is a major customer both in space launch services and in-space services. As such, the way it awards contracts and purchases capabilities can deeply affect the viability of companies in the space economy. The U.S. government can take steps to ensure that its consumption of space services promotes the commercial market—primarily in terms of the commercial *launch* market.

Space Launch Market

The private launch industry has certainly made dramatic steps forward in recent years—especially with the progress of partially reusable rockets.[188] However, the government's share of the launch service market means federal policies still have an outsized effect on which companies survive in the market. Policies that made sense when there was one certified source for national security launches no longer make sense when there are competitors.

Of course, the United States military and intelligence services need to maintain their assured access to space. This is especially important in heavy-lift capability—the rockets that lift large, heavy national security satellites into orbit. However, as multiple companies develop new heavy launch capabilities,[189] even that market should be able to move towards healthy competition. There is a growing

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[187] Swarts, Phillip, "U.S. Air Force awards commercial space-surveillance contract," *SpaceNews*, Oct. 31, 2016, http://spacenews.com/u-s-air-force-awards-commercial-space-surveillance-contract/.
[188] De Selding, Peter, " SpaceX's reusable Falcon 9: What are the real cost savings for customers?," *SpaceNews,* April 25, 2016, http://spacenews.com/spacexs-reusable-falcon-9-what-are-the-real-cost-savings-for-customers/.
[189] SpaceX, *Falcon Heavy* http://www.spacex.com/falcon-heavy. Clark, Stephen, "Details of Orbital ATK's proposed heavy launcher revealed," *Spaceflight Now*, May 27, 2016,

opportunity to help push launch markets into the type of market competition that will continually produce innovation solutions for both commercial and government clients. It will require changes to how the government buys launch services.

The DOD and USAF should review their current contracts and policies for launch services. Direct support for infrastructure and capacity, while useful during the era of single-sourced launches, should be responsibly phased out.[190] The launch industry is no longer in the same fragile state that merited contracts for such support,[191] and in a competitive market propping up infrastructure helps neither entrants to the market nor the incumbents. The incumbent is not incentivized to innovate the next generation of technology because the support rests on maintaining the current infrastructure and capability, and entrants are handicapped by not receiving infrastructure support.

These are not new arguments. In the 1990s, the USAF shifted to purchasing launch services from commercial providers.[192] The government had anticipated an increase in demand from the commercial space market that would, after initial development funding from the government, help pay for the commercial providers' launch systems.[193] That demand did not materialize, and spiraling costs eventually forced the two providers to merge into ULA.[194] The question today is whether the demand for launches has changed enough to merit a new attempt at promoting competition, or if a repeat of the challenges of the 1990s is likely.

There are substantial differences today that may make a competitive launch market more viable, however. First, the rise of new market entrants has increased the potential for competition. While these new entrants have needed government contracts and development support, they did not begin as projects pitched by the government to traditional government contractors. Selling to the commercial market was part of the calculus from the beginning. That calculus meant focusing on driving costs down, even though that increases potential risk.[195] Those lower costs, though, broaden the potential commercial market by increasing access to launch services. The industry has seen a rise in interest in low-cost satellites, driven by entities that had been priced out of the traditional market.[196] Instead of focusing on providing a 100 percent reliable launch service first, and then reducing costs to appeal to commercial launches, these new launch entrants have started by focusing on competitive costs and then building up the track record for reliability.

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https://spaceflightnow.com/2016/05/27/details-of-orbital-atks-proposed-heavy-launcher-revealed/. Bennet, Jay, "Blue Origin Announces Huge Heavy Lift Rocket to Rival SpaceX's Falcon 9," *Popular Mechanics*, Sept. 12, 2016, http://www.popularmechanics.com/space/rockets/a22813/blue-origin-announces-new-glenn-rocket/.

[190] Gruss, Mike, "U.S. Air Force evaluating early end for ULA's $800 million in yearly support," *SpaceNews*, Jan. 27, 2016, http://spacenews.com/u-s-air-force-looks-at-ending-ulas-launch-capability-payment/.

[191] Smith, Marcia, "Hyten: No "Fair Competition" If ULA Contract Remains," *SpacePolicyOnline* April 7, 2015, http://www.spacepolicyonline.com/news/hyten-no-fair-competition-if-ula-contract-remains.

[192] Maj Gregory Wood, USAF, "The Evolved Expendable Launch Vehicle," *Air & Space Power Journal*, Summer 2006, http://www.au.af.mil/au/afri/aspj/airchronicles/apj/apj06/sum06/wood.html.

[193] Ibid.

[194] Ibid.

[195] Berger, Eric, "ULA executive admits company cannot compete with SpaceX on launch costs," *Ars Technica*, March 17, 2016, http://arstechnica.com/science/2016/03/ula-executive-admits-company-cannot-compete-with-spacex-on-launch-costs/.

[196] [redacted], "Commercial Space Industry Launches a New Phase,"*Congressional Research Service,* Dec. 12, 2016, https://www.everycrsreport.com/files/20161212_R44708_a35133df2d936afd171d81bb13f6f60f4a89821f.pdf.

That is not to say that the DOD and USAF could not provide some support to the wider market for needs currently unmet. For heavy launch systems, for example, the DOD should continue to use public-private partnership contracts to incentivize investment. This is what it has done in working with Orbital ATK for new engine development, for example.[197] Those contracts, paid for direct development of a service, do not skew the markets as much as payments for capacity do. It is also important, though, that if the government does need to award funds for a required capability, that it does so across the industry. Any firm that receives sole support from the government would gain an unfair advantage in both the market for government contracts, but also in the wider commercial market. The government must be careful to not play favorites.

Where possible, the government should purchase services instead of building its own systems. For this to be properly competitive, the government will need to use the same contract types for the bidding companies. At the moment, the certified defense launch companies operate under two different types of contracts.[198] This results in different cost burdens due to varying requirements under the contracts. Before the launch industry recently became competitive, the USAF used cost-reimbursement contracts. These contracts required intensive reporting from ULA, the only certified launch company, to ensure fair prices.[199] With nascent competition in launch services, fixed-price contracts could be used and the reporting requirements rolled back. The USAF will lose significant information it has on the internal workings of the companies providing launch,[200] but the decision would be fairer across the two currently certified launch companies and lower a significant barrier to entry.

With lower barriers to entry, the odds of a robust and competitive commercial launch market increase. Such a market would lower costs of launch, reducing access for more commercial actors and lowering prices for government agencies. The type of innovation already seen in space would be furthered, as would the growth of the U.S. space economy. At the same time, the ability for the United States to quickly launch new defense systems, or reconstitute existing systems, would be strengthened.

None of these steps will be easy, and the launch market is perhaps the most difficult area of the space economy for the government to manage. The United States has to promote competition (not just for competition's sake, but to reduce costs and spur innovation), while also maintaining confidence that it has two ways of accessing space. While the launch market is more competitive than it has been, there are also substantial challenges. One defense-certified launch vehicle relies on Russian-built rockets,[201]

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[197] Clark, Stephen, "Orbital ATK, SpaceX nab U.S. Air Force propulsion contracts," *Spaceflight Now*, Jan. 14, 2016, https://spaceflightnow.com/2016/01/14/orbital-atk-spacex-nab-u-s-air-force-propulsion-contracts/.

[198] SpaceX was awarded a fixed-cost contract (*see generally* Messier, Doug, "Air Force Awards GPS III Launch Services Contract to SpaceX," *Parabolic Arc,* April 27, 2016, http://www.parabolicarc.com/2016/04/27/air-force-awards-gps-iii-launch-services-contract-spacex/.); Alternatively, ULA operates under a cost-reimbursement contract. (*see generally* U.S. Government Accountability Office, *Evolved Expendable Launch Vehicle: The Air Force Needs to Adopt an Incremental Approach to Future Acquisition Planning to Enable Incorporation of Lessons Learned*, Aug. 11, 2015, http://www.gao.gov/products/GAO-15-623.)

[199] U.S. Government Accountability Office, *Evolved Expendable Launch Vehicle ...*, Aug. 11, 2015, http://www.gao.gov/products/GAO-15-623.

[200] Ibid.

[201] United Launch Alliance, Atlas V: Maximum Flexibility and Reliability, http://www.ulalaunch.com/products_atlasv.aspx

one is no longer commercially viable,[202] and the newest has also had its issues.[203] The United States has to promote new options to replace its older launch vehicles, but in doing so could skew the market and kill of entrants. Fundamentally, however, a successful transition to new, affordable launches will rely on a competitive market being maintained.

Non-Launch Services

The promotion of commercial outer space should not just focus on launch services, but also in-orbit tools such as communications and remote sensing. The U.S. government has the opportunity to use burgeoning commercial capabilities in those markets as well, but it should make it easier for Americans to invest and compete in them.[204]

It is also important to remember that commercial demand for launch services will be vital to future development of cheaper, more innovative launch services. Commercial actors already control over 70 percent of the market, and that number will likely increase.[205] Low launch costs are fueling a surge in investments in space-related business, and those investments will fuel more lanches.[206] The money that launch companies will get from companies wanting to put satellites, or other assets, into space will fuel improvements to launch services and further reduce costs. This virtuous cycle will have two effects: (1) America's space economy, and so its wider economy, will grow; and (2) innovations in launch services that are cheaper, but riskier, will be tested in the commercial sector and can then be used for government launches when proven safe.

The DOD has already argued that working with commercial providers for needed services has benefits. Tying commercial assets into defense systems can reduce costs and strengthen defense capabilities by reducing the likelihood that vulnerabilities in a system are replicated across the entire network.[207] If the United States can then purchase a range of commercial in-orbit tools, or piggyback hosted payloads on commercial satellites, it may further drive progress in the commercialization of outer space. Competition for providing in-orbit services would increase, reducing costs, and launch prices may fall with even higher demand for launches.

How Government Allows Space Business

Finally, the United States also needs to look at how it allows space business to be conducted. Organizational changes may allow the government to be better positioned to consider policies and regulation, and government business reforms may ensure that markets are not skewed too much.

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[202] Mehta, Aaron, "ULA to Retire Delta IV, Push for More RD-180s," *DefenseNews*, March 15, 2015, http://www.defensenews.com/story/defense/air-space/space/2015/03/15/ula-delta-iv-retire-rd180-russia-spacex/70231994/.

[203] Klotz, Irene, "SpaceX Finds Rocket Explosion 'Smoking Gun,'" *Space.com*, Nov. 7, 2016, http://www.space.com/34641-spacex-elon-musk-falcon-rocket-explosion-launch-pad-accident.html.

[204] CSIS, "The U.S. Military and Commercial Space Industry," October 24, 2016, https://www.csis.org/events/us-military-and-commercial-space-industry.

[205] The Space Foundation, *The Space Report: The Authoritative Guide to Global Space Activity*, 2016, http://www.spacefoundation.org/sites/default/files/downloads/The_Space_Report_2016_OVERVIEW.pdf.

[206] Masunaga, Samantha, "Why investment in space companies is heating up," *Los Angeles Times*, July 7, 2016, http://www.latimes.com/business/la-fi-qa-space-investment-20160707-snap-story.html.

[207] CSIS, "The U.S. Military and Commercial Space Industry."

Responsible policies, however, will be the most important aspect of healthy commercial space market.

The United States benefits from promoting as large a space economy as possible. Such an economy would drive innovation and promote growth. For the government, a freestanding space economy would drive down costs of launches and services. How then should the government approach its space regulations? While the commercial space market is perhaps in a better shape than it ever has been, it still is relatively fragile.[208] While this paper has mentioned the various pressures that are growing on the U.S. government to review its space regulation, those pressures themselves do not mean that the United States should regulate for regulation's sake. For example, in some cases the solution may simply be clarifying the decision process and enabling a review process.

In approaching commercial space, government agencies should take as light-touch an approach as possible. Missions should be default-approved, with the burden of proof on the government to demonstrate that a particular mission would be risky to the public or national security. If within a standard period of time the government cannot articulate a specific reason as to why the mission should not move forward, it should be permitted. The application process for missions should be clearly articulated, and decisions should be consistent across applications from different companies. Informal processes should be formalized. Decisions made for national security reasons should at least be traceable, in case review is necessary.

There should also be a public review process for challenging decisions. The remote sensing industry is an example of what can happen when overly burdensome regulations are put into place: American businesses are handicapped and industry advantage shifts to foreign competitors. In this regard, current policies that are archaic should also be revisited. The licensing process for remote sensing, for example, has been criticized as arbitrary.[209] The result, at least from the commercial viewpoint, has been that non-governmental remote sensing is provided mostly by non-American companies.[210] The review of the export control system should also continue, with regular updates.[211] The specificity of the restrictions means that they can become obsolete quickly, with non-American companies producing equipment American companies are constrained from selling abroad. In reviewing these processes and systems, the goal should be that the space market becomes self-supporting rather than a simple privatization of government tasks.[212]

The government can also avoid creating regulations to manage issues that could be managed under existing law. It is possible, for example, that tort law could be used to manage some of the possible issues of outer space, at least in issues between two American companies. Outer space is not a single policy area which requires a one-size-fits-all approach. There are a range of issues with a range of analogs in existing domestic and international law, and there will be a range of potential solutions to those particular issues. Space mining may be analogous to deep sea exploration, while debris clean-up

[208] Dorminey, Bruce, "NewSpace Sector Is Likely Facing Recession," *Forbes*, Nov. 15, 2016, http://www.forbes.com/sites/brucedorminey/2016/11/15/newspace-sector-is-likely-facing-recession/#48dc4a4ed09a.
[209] Foust, Jeff, "House panel criticizes commercial remote sensing licensing ," *SpaceNews*, Sept. 8, 2016, http://spacenews.com/house-panel-criticizes-commercial-remote-sensing-licensing/.
[210] Ibid.
[211] Foust, Jeff, "Federal government tweaks space export control rules," *SpaceNews*, Jan. 12, 2017, http://spacenews.com/federal-government-tweaks-space-export-control-rules/.
[212] CSIS, "The U.S. Military and Commercial Space Industry."

in orbit would require international agreements and coordination. Maturity levels of different parts of the industry will also inform different approaches.

Regulations, if found to be necessary, should be consistent, unambiguous, and specific. The process for rulings on decisions should be transparent and consistently applied. The government should avoid using catch-all categories and should instead specifically draft the rules for individual activities in space if needed. The government should also remember that the OST is not self-executing. Although there could be international consequences for decisions made about whether to regulate an activity in space or not, the United States has leeway in determining what needs authorization and how intensive "continuing supervision" needs to be.[213] The United States also should not try to guess what commercial uses of outer space may become viable or not. It is important to remember the lesson of AT&T's 1960 license application: the commercial sector may surprise the government in what the latter believes to be viable.[214]

Because of Article VI mandate in the OST and the complexity of the issues at play, avoiding burdensome regulation is the hardest policy suggestion. The mere presence of complexity, however, does not mean that the government should err on the side of overly restrictive policies, especially when the benefits to liberalizing the regulations in this industry are so pronounced.

Conclusion

This recommended list of actions does not exhaust the possibilities for how the U.S. government can promote commercial outer space. New and complex problems will certainly arise in the future. For now, these proposals can help the United States realize the full potential of outer space for private actors and the government alike. Elevating space policy to a higher level within the government, codifying an attitude of openness to innovation, and making sure that any regulations—if needed—are up-to-date, clear, and reliably applied are key to realizing the benefits of space.

A growing and robust commercial space economy will facilitate economic growth and promote domestic national security. The same incentives that drive innovation in the competitive, commercial sector will, over time, reduce the costs and increase the capabilities of American security space systems. Innovations in satellite technology will change how parts of the economy operate, and how the U.S. military projects power abroad. Cheap launch services can open Earth's orbit and beyond to larger markets, eager entrepreneurs, and new inventors. Those services could also allow the United States to create a more resilient defense network in orbit and, if necessary, quickly reconstitute it.

There are many challenges that stand in the way of that market—from the sheer difficulty of going to space to the geopolitical and legal complexities involved—but now is the time to get serious about crafting good space policy. The decisions in the next couple of years could define access to space, and the benefits we reap, for generations to come. The United States must decide between a risk-averse approach—restraining the market and ceding exploration and investment to more adventurous

[213] United Nations Office on Space Affairs, *United Nations Treaties and Principles on Outer Space*, United Nations, 2002, http://www.unoosa.org/pdf/publications/STSPACE11E.pdf.
[214] Whalen, David, "Communications Satellites: Making the Global Village Possible," *NASA History Division*, Nov. 20, 2010, http://history.nasa.gov/satcomhistory.html.

nations—and an optimistic and permissive approach, with intervention only when it is clearly necessary.

The rise of a commercial space market will not necessarily be uneventful. There will be failures, and some of the optimistic companies that exist today will succumb to competitors or the difficulty of the task at hand. Investments in space will ebb and flow.[215] But there will be no groundbreaking innovation if we refuse to tolerate failures and allow the market to mature. Public safety, especially for launches, must remain a concern, but that does not have to come at the expense of promoting growth and defending national security.

The United States is on the cusp of having an independent commercial space market. With a few smart decisions and a policy of regulatory restraint, the government can simultaneously promote innovation, growth, and national security, while proving that enterprise in space does not require the backing of a large nation state. That would be a giant leap for mankind.

[215] Dorminey, Bruce, "NewSpace Sector Is Likely Facing Recession," *Forbes*, Nov. 15, 2016, http://www.forbes.com/sites/brucedorminey/2016/11/15/newspace-sector-is-likely-facing-recession/#1485c9bcd09a.

Afterword

Late last year, Elon Musk presented his long-awaited plan detailing a manned mission to Mars. It was technically-informed, daring in its truncated timeline, and just a little bit audacious. In short, it was everything we've come to expect from the man. As Musk concluded his presentation, he argued we should all be dreaming just a little bit bigger. "Life needs to be more than just solving problems every day," he said. "You need to wake up and be excited about the future." With all the exciting recent developments in the space industry, those words are an inspiring call to action.

Musk's plan is a bold undertaking and its success is far from guaranteed. Yet in the shadow of the Tesla tycoon's grandiose aims lies an assuredly actualizable goal: the commercialization of space.

The legal, regulatory, and international challenges ahead are surmountable, but we should not be under any illusion that it will be an easy path ahead. We will need to establish a clear regulatory framework to ensure certainty and accountability in order to grow investment and spur further innovation. National security considerations will be of paramount importance, lest the specter of space-based conflict leaves this burgeoning marketplace grounded. The international implications of near-Earth orbit competition will necessitate greater cooperation between commercial launch providers, space-based service firms, and, perhaps most importantly, nation-states. What is needed now, more than ever, is a serious and committed partnership between governments, nonprofits, and industry players the world over.

Here in the United States we can play a significant role in catalyzing that partnership. The U.S. government should venture to promote a closer working relationship between the emerging commercial launch industry and national security stakeholders. By first ameliorating domestic concerns, our country can take the lead in unlocking the final frontier for all of humanity. And in the wake of the aperture we open, others will surely follow.

Luckily, much of the groundwork has already been laid for what lies ahead. SpaceX, Orbital ATK, Blue Origin, Virgin Galactic, Moon Express, and other visionary companies have already set the stage for our journey to the wider solar system. Nurturing this ecosystem of emerging space launch competitiveness and bringing down launch costs will be the first step in this longer journey, and we're already well on our way.

While starry-eyed optimism can keep the ultimate goal of commercializing, colonizing, and conquering space in focus, we must bear in mind that such a realization remains on the horizon. The barriers here are real and significant. With such a daunting task ahead, we should move forward with clear goals and clear heads—dreaming big and embracing the exciting potential before us, while taking it one sober, practical step at a time.

This paper, and the recommendations it outlines, is one such step towards moving the private space sector onto more solid ground. By promoting the Office of Commercial Space Transportation to a sub-cabinet administrative unit, the U.S. government can communicate its commitment to the importance of the commercial space sector and help create the legal and regulatory certainty necessary to catalyze further investment and innovation. Handing commercial space situational awareness to a nonprofit organization with a globally-focused multi-stakeholder arrangement can

help alleviate international concerns. It would also deflect criticisms of American hegemonic expansion into space while helping to dutifully address international space-based coordination issues.

There are still many hurdles to overcome and we must be mindful of them. Yet we shouldn't let that reality temper our optimism, nor lead us to exuberantly embrace the status quo at the cost of welcoming the future. We should be excited about the possibilities of becoming a true multi-planetary, space-faring species. Humanity's future lies amongst the stars. It's up to us to figure out the best path to get there so that all of us may share in the common heritage of mankind. If we can get the rules right, the sky will no longer be the limit.

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