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Threats to U.S. Competitiveness in Space: Oral and Written Statements for the 21 February 2018 Meeting of the U.S. National Space Council

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Verbal Opening Statement by Bhavya Lal, Ph.D.

Mr. Vice President and Members of the National Space Council. A discussion on the threats to U.S. competiveness in space needs to start with the acknowledgement that we are the preeminent space power in the world today. The U.S. Government still spends more on space than the rest of the governments in the world combined. The United States has more satellites and other assets in orbit than any country in the world. The world's currently most powerful rocket, launched just two weeks ago, is the product of American industry. A recent study on global trends in small satellites by my organization, the IDA Science and Technology Policy Institute, found that about two-thirds of the 100 organizations doing the most innovative R&D in the smallsat sector are U.S.-based.

These advantages cannot, however, be taken for granted, and our leadership in space is increasingly being challenged. Other countries have observed the geopolitical benefits, economic opportunities, and prestige that have come to us as an outcome of our leadership in space; and global investments in space have steadily grown over the past two decades. A decade ago, for instance, fewer than 50 countries were investing about $40 billion in space. By 2026, 30 more countries are expected to join the space club, and global expenditures on space are expected to be double those of 10 years ago.

Growing international expenditure is only one development in the space sector. Partially as a result of investments from the U.S. Government, there have been dramatic improvements in the technology used in the space sector. In some areas, costs have fallen by orders of magnitude. Using a combination of alternative architectures such as swarms of hundreds of small satellites, and business process innovation, relatively inexpensive breadbox-sized satellites are able to nearly match services that were previously feasible only with bus-sized satellites that cost hundreds of millions, if not billions, of dollars. Buoyed by the perception of profitability, space has become an attractive target for private investment—almost $17 billion since 2000; and $4 billion in 2017 alone. As a result, some sectors of space are transitioning from top-down government-led operations to a globalized industry with worldwide supply chains and customers. Using both domestic investment and products and services from this rapidly growing private sector, the rest of the world is leapfrogging decades-worth of technological development, aiming to build systems that can compete with the United States in many areas including launch, robotic space operations, and even human exploration. My central point is that *threats to U.S. leadership in space have arisen primarily from these structural changes that are enabling many more countries to target and achieve successes in space. And there is no going back.*

In this environment, maintaining U.S. leadership means that the United States, more than ever, needs to leverage its core competitive advantage—an innovation ecosystem that rewards creativity, risk-taking and entrepreneurship. Going beyond the fundamentals, there are some space-sector specific actions that would be relevant as well. I propose we begin with three. First we need to ensure that our regulations empower the U.S. private sector to continue to out-innovate the rest of the world. Second, we need to ensure government spending is more efficient. Lastly, we need to invest in capabilities where we absolutely must have overwhelming advantage over other countries. I look forward to contributing to this discussion.

References

Lal, B., E. de la Rosa Blanco, J. Behrens, B. Corbin, E. Green, A. Picard, and A. Balakrishnan. "Global Trends in Small Satellites." July 2017. Available at: https://www.ida.org/idamedia/Corporate/Files/Publications/STPIPubs/2017/P-8638.pdf.

Lal, B., E. Sylak-Glassman, M. Mineiro, N. Gupta, L. Pratt, and A. Azari. "Global Trends in Space." Volume 1. June 2015. Available at https://www.ida.org/idamedia/Corporate/Files/Publications/STPIPubs/2015/p5242v1.ashx.

Threats to U.S. Competitiveness in Space

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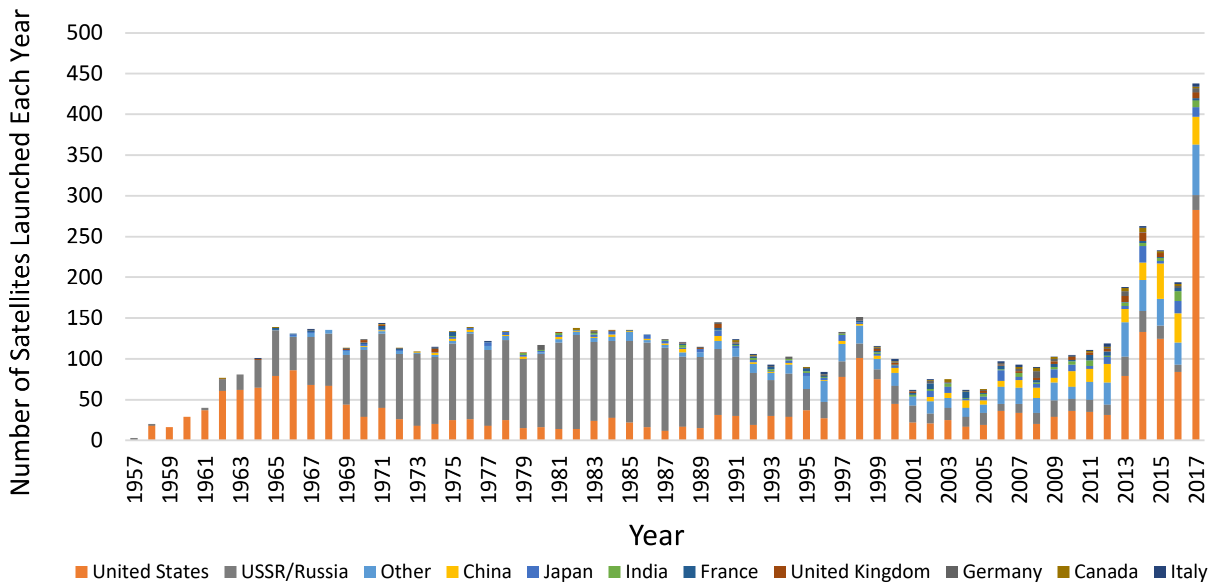
In the discussion on threats to our international competitiveness, it is important to first acknowledge that the United States is the most competitive space power in the world *today*, the result of a large and long-term investment we made to achieving space superiority. The U.S. Government spends more on space than the rest of the world's governments combined.[1] Outcomes reflect this investment, and the United States plays a leadership role in space by almost all metrics of interest. Furthermore, government activity is just one element of this leadership. The world's most powerful rocket today, launched just two weeks ago, is the product of American industry. Of the approximately 450 satellites launched in 2017, nearly two-thirds were American (Figure 1) and most of those were commercial (dominated by Planet and Spire). The private sector is also the driver of one of the most dramatic recent changes in the space sector—highly capable small satellites. A recent study on global trends in small satellites by my organization, the IDA Science and Technology Policy Institute, found that there are almost as many U.S. companies developing smallsat launchers as in the rest of the world, combined (Figure 2). Eleven of the 16 smallsat constellations under development are by U.S.-based firms, and more than 60 of the 100 organizations doing the most innovative technology development worldwide are U.S.-based.[2] Two-thirds of the private investors in the smallsat sector are in the United States. U.S. companies have manufactured 90 percent of commercial smallsats launched between 2012 and 2017, and two U.S. companies account for more than three-fourths of commercial smallsats launched in this timeframe.[3]

1 Aerospace Industries Association (AIA), *Engine For Growth: Analysis And Recommendations for US Space Industry Competitiveness*, May 2017. Available at https://www.aia-aerospace.org/report/engine-for-growth-analysis-and-recommendations-for-u-s-space-industry-competitiveness/.

2 B. Lal, E. del a Rosa Blanco, J. Behrens, B. Corbin. E. Green, A. Picard. A. Balakrishnan, "Global Trends in Small Satellites," July 2017. Available at https://www.ida.org/idamedia/Corporate/Files/Publications/STPIPubs/2017/P-8638.pdf.

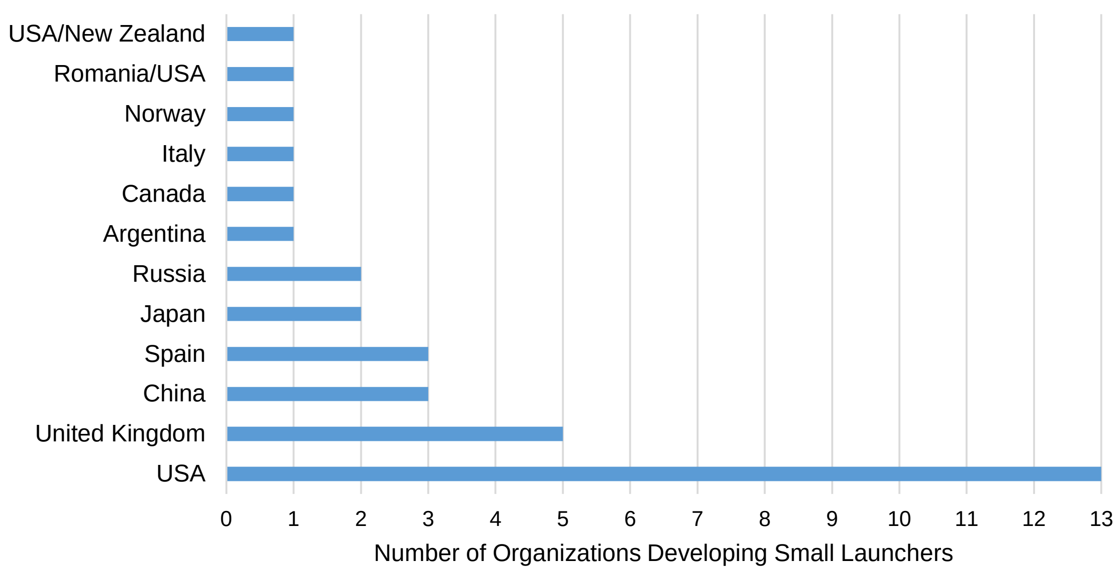
3 Bryce Space and Technology, *Smallsats by the Numbers*, February 2018. Available at https://brycetech.com/downloads/Bryce_Smallsats_2018.pdf.



Source: J. McDowell, "Satellite Catalog," 2018.

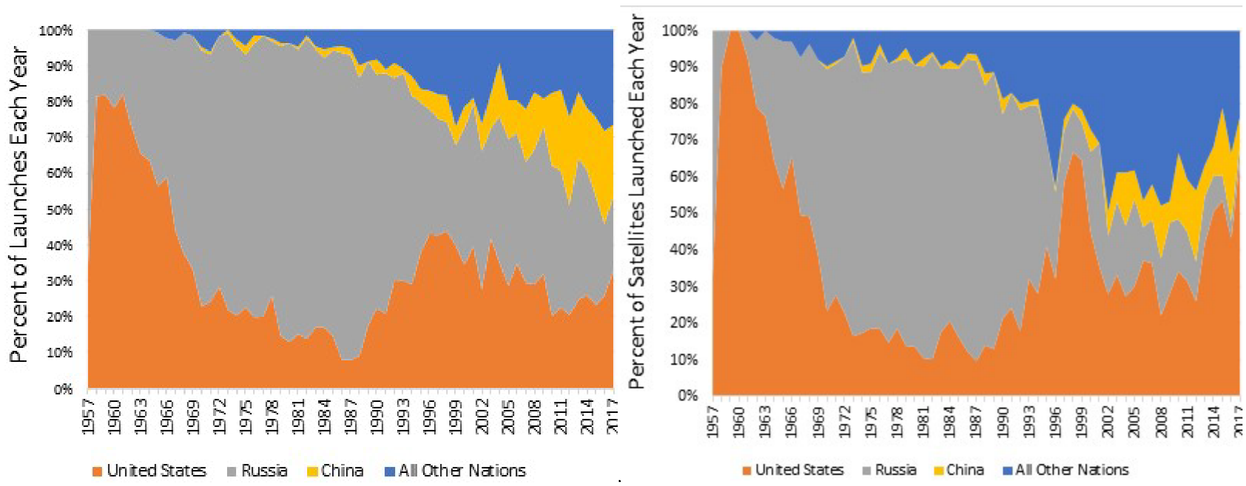
Note: The numbers for the Soviet Union are added to the numbers for Russia. The high number of satellites in recent years is related to growing number of CubeSat launches.

Figure 1. Total Number of Satellites Launched by Country



Source: Lal, de la Rosa Blanco, Behrens et al., "Global Trends in Small Satellites."

Figure 2. Number of Small Satellite Launchers in Development by Country with Plans to be Operational Between 2017 and 2021



Source: J. McDowell, “Satellite Catalog,” 2018.

Note: The numbers for the Soviet Union are added to the numbers for Russia.

Figure 3. Fraction of Launches (LHS) and Satellites Launched (RHS) by the United States and Other Countries

Despite these accomplishments, U.S. leadership in space is increasingly being challenged. Many countries have noted U.S. successes in space and the geopolitical advantages, economic opportunities, and prestige that have accrued to the United States as a result. Global investments in space have steadily grown over the past two decades. A decade ago, fewer than 50 countries were investing in space—today there are 70. In the coming decade, we expect that number to increase to more than 80 countries, and the average annual expenditure globally is expected to double, from about $40 billion in 2006 to $80 billion in 2026.[4] The increasing commitment of other countries in space is reflected in the growing fraction of satellites and launches by countries other than the United States and Russia, the two original spacefaring nations (Figure 3).

As countries invest more in space and partner with others, they are developing capabilities that may ultimately challenge America’s technological lead in some areas. For example, India and the United Arab Emirates are developing deep space probes and landers on the Moon and Mars, with plans to return samples; and others such as Israel, Singapore, South Korea, and the United Kingdom, have begun to excel in niche areas such as space avionics, alternative approaches to launch, and data analytics applied to space-derived imagery. Indeed Japan is the only country in the world that has actually returned a sample from an asteroid, and Europe the only region that has landed a probe on a comet. To ensure their interests are represented in governance of space, membership in international institutions is growing as well (Figure 5). In the STPI database of organizations engaged in smallsat activity, for example, over half were outside the United States, and spread across 70 countries (Figure 4). Several of these countries are poised to become major space players, and may rival the United States in key areas in a few years.

4 EuroConsult Government Space Programs Benchmarks, Profiles & Forecasts to 2026, 2017. Available at http://euroconsult-ec.com/research/government-space-programs-2017-brochure.pdf.

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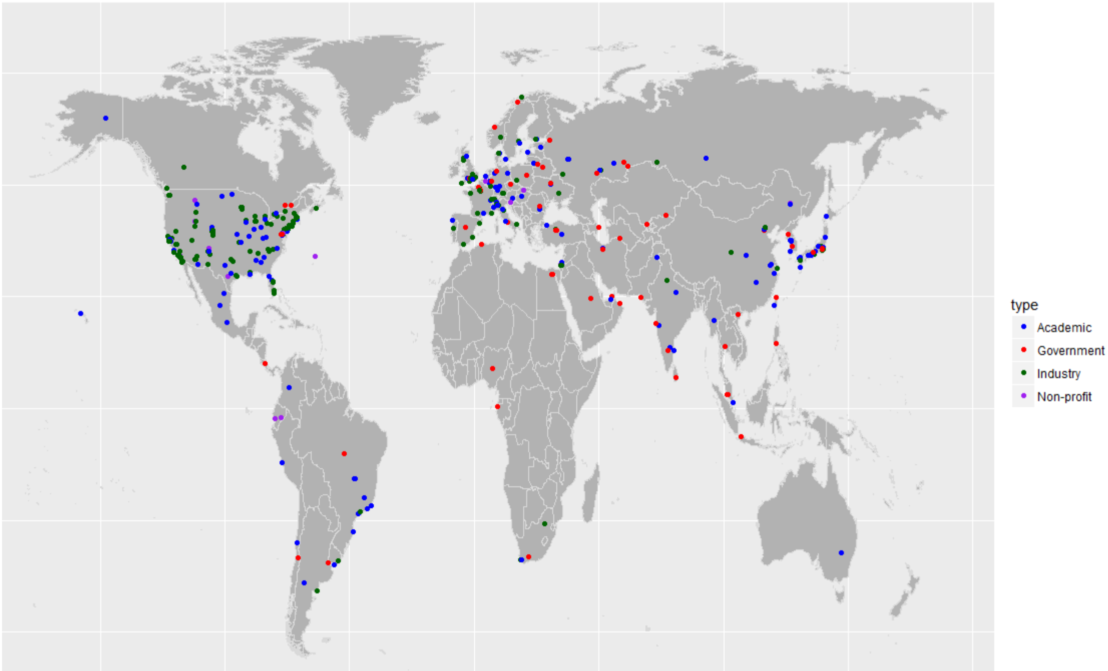
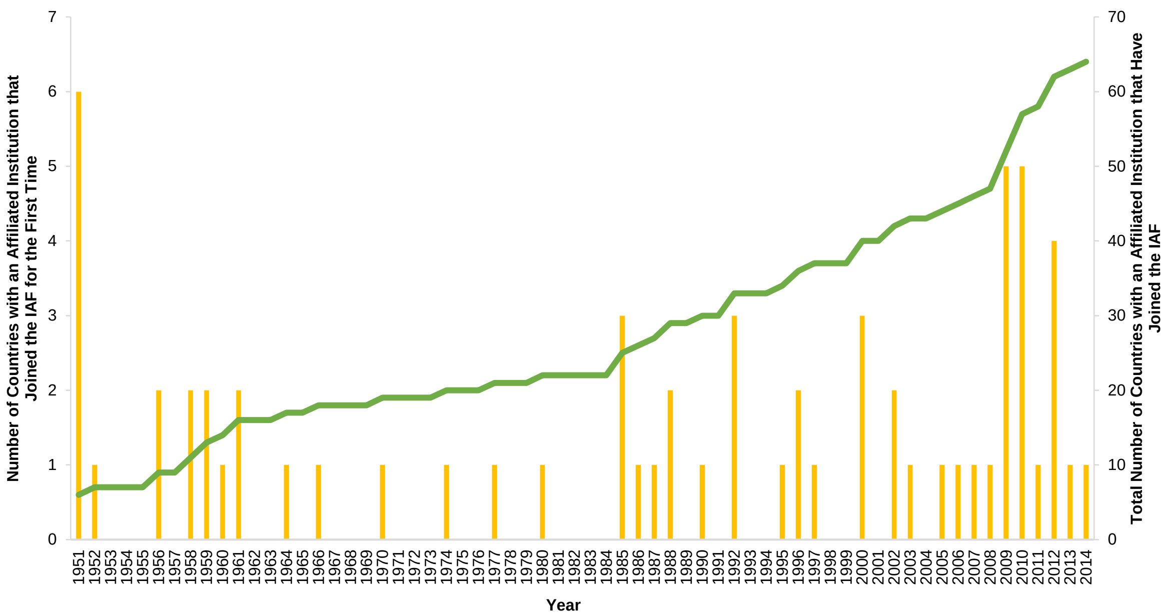


Source: Lal, del a Rosa Blanco, Behrens et al., "Global Trends in Small Satellites."

Figure 4. Global Distribution of Smallsat Organizations, Based on Indicated Headquarters (*n* = 664)



Source: Lal, Sylak-Glassman, Mineiro et al., "Global Trends in Space."

Figure 5. International Astronautical Federation (IAF) Membership Over Time

Global space activities are being affected by fundamental structural changes in the space sector: dramatic improvements in technology, falling costs, and perceptions of profitability have enabled some parts (such as earth observations and communications) of the space sector to attract private funding at unprecedented levels—almost $17 billion since 2000, and $4 billion in 2017 alone.[5, 6] These structural changes are contributing to the rapid growth of the private space sector not just in the United States but globally. NewSpace Ventures lists almost 1700 "newspace" entities in 2017, 55% of which were located outside the United States.[7] Satellite and component manufacturer Gomspace originated in Denmark; low-power synthetic aperture radar (SAR) constellation operator ICEYE started in Finland; on-orbit assembly and geospatial intelligence company Kleos emerged in the UK and is operating out of Luxembourg; space debris removal company Astroscale came out of Singapore and Japan; Infostellar, a start-up that provides an AirBnB-like model for sharing ground stations, originated in Japan; and the company Sky and Space was started in Israel, is registered in the UK, traded in Australia, its satellites are built in Denmark, and launched by Indian and U.S. rockets.

Most of these organizations have funds from international investors, private and sovereign, and all aim to serve domestic and international customers. As in other mainstream sectors such as IT, these companies have global operations and ambitions for a global customer base. By doing so, they are fundamentally democratizing access to and use of space. It is no longer necessary for most countries to develop indigenous capabilities to benefit from space. A country can now own space assets simply by purchasing them from turnkey providers such as Surrey Satellite in the UK. A government can buy data and services rather than manufacturing and operating satellites by partnering with firms such as Germany-based Berlin Space Technologies that will do it all for them.[8] By investing in foreign firms, whether it is the government of Luxembourg in Planetary Resources, a U.S.-based asteroid mining firm, or that of China in Satellogic, an Argentina-based high resolution hyperspectral imaging company, governments can drive companies' business plans, such as decisions to locate R&D or manufacturing facilities.

Countries with emerging space capabilities have other advantages as well. Since many are creating their space institutions from the ground up, they are not locked into the same legacy institutional structures as in historically spacefaring countries such as the United States. An analogy is telecom; many developing countries skipped straight to wireless communications rather than duplicating a landline infrastructure. To an extent, countries can do the same for space systems. Instead of machining and welding rocket engines, they may be able to 3D-print them, and instead of trying to stitch together regulatory systems split across multiple agencies as in the United

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5 Bryce Space and Technology, *Start-Up Space 2017: Update on Investment in Commercial Space Ventures*, 2017.

6 Space Angels Network, Space Investment Quarterly Q4 2017.

7 NewSpace Ventures, "NewSpace Ventures Analytics." Available at https://mission-control.space/.

8 Recently, the Turkmenistan Ministry of Communications contracted with the Italian/French multinational company Thales Alenia Space to build a satellite called TurkmenÄlem52E/MonacoSat. It was launched by the U.S.-based SpaceX, and is operated by the Monaco-based satellite operator Space System International-Monaco.

States, they can create more streamlined regulations. This kind of leapfrogging is accelerating the progress of other countries' space-related efforts.

My central thesis is that threats to U.S. leadership in space arise not from any major stumbles the nation made, but primarily from structural changes which are enabling more countries to have successful space programs; a whole new class of technologies not under U.S. control, and the emergence of new business models which are changing the way countries conduct their space activities. Maintaining U.S. leadership in the face of these threats means that the United States, more than ever, needs to leverage its core competitive advantage—an innovation ecosystem that rewards creativity, risk-taking and entrepreneurship.

The fundamentals of this "innovation ecosystem" are sound. The United States still invests the most in R&D, still attracts the most venture capital, and still awards the largest number of advanced degrees in the world.[9] Thanks to these investments, the United States is still home to the most innovative people and ideas in the world—whether developing reusable rocket boosters, entirely 3D-printed rockets, or advanced in-space propulsion systems. However, the global competitiveness of the United States in space and other areas could be threatened if we allow elements of this innovation ecosystem—world class universities, an immigration system that emphasizes high-tech skills, and a supportive regulatory environment, among others—to weaken, especially as other countries are strengthening their innovation ecosystems. China, for example, has increased its research and development (R&D) spending rapidly since 2000, at an average of 18 percent annually.[10] During the same period, U.S. R&D spending grew by only 4 percent per year. Although emerging economies start at a lower base and therefore tend to grow more rapidly in percentage terms, China's growth rate is exceptional by any standard. Venture capital for all types of activities in China rose from approximately $3 billion in 2013 to $34 billion in 2016, climbing from 5 to 27 percent of the global share—the fastest increase of any economy.[11] Space as an expression of technological advancement has been a beneficiary of this growth.

There are some worrisome trends on the horizon, an example being the future aerospace workforce. International students, until recently, comprised 59 percent of our graduate programs in science and engineering, with most staying here after completing their studies. In recent years, the number of these students in the United States has dropped, with the largest declines seen at the graduate level in some of the most relevant fields—a 13 percent decline in computer science, and an 8 percent decline in engineering. This is not a welcome trend in the bedrock of our innovation system. Elon Musk came to this country as an undergraduate student. We need to ensure that future Musks of the world want to learn, live, and innovate in the United States.

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9 National Science Foundation, "Science and Engineering Indicators 2018," NSB-2018-1, and "Digest," NSB-2018-2, January 2018. Available at https://www.nsf.gov/news/news_summ.jsp?cntn_id=244271.

10 National Science Foundation, "Science and Engineering Indicators 2018."

11 By comparison, the U.S. attracted nearly $70 billion, accounting for slightly more than half of the global share.

Going beyond the fundamentals, there are some space-sector specific actions that would be relevant as well. I propose we begin with three. First we need to ensure that our regulations empower the U.S. private sector to continue to out-innovate the rest of the world. Policies related to remote sensing (on ground and in space), spectrum allocation, and barriers to international trade need to be nimble, flexible and not get outpaced by new applications in space or disruptive technology development. Second, we need to ensure government spending, where we are likely to continue to face fiscal constraints, is sensible—for example, space agencies need to continually consider where solution-based contracting would be more efficient than requirements-based contracting. Last, but not least, and again in light of these fiscal realities, we need to make tough choices and select capabilities where we absolutely must have overwhelming advantage over other countries, and invest in those above all others. I look forward to contributing to this discussion.

Further Reading

Lal, B., E. de la Rosa Blanco, J. Behrens, B. Corbin, E. Green, A. Picard, and A. Balakrishnan. "Global Trends in Small Satellites." July 2017. Available at: https://www.ida.org/idamedia/Corporate/Files/Publications/STPIPubs/2017/P-8638.pdf.

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Bhavya Lal, Ph.D., is a researcher at the IDA Science and Technology Policy Institute (STPI), a Federally Funded Research and Development Center established by Congress to support the White House Office of Science and Technology Policy (OSTP) and other Executive Branch Agencies. STPI is operated by the Institute for Defense Analyses (IDA), a non-profit corporation established to provide objective analyses of national security and other national challenges. At STPI, Dr. Lal leads analysis of space technology, strategy, and policy for OSTP, the National Space Council, NASA, the Office of the Director of National Intelligence, Federal Aviation Administration, and other Federal agencies and departments. She is the co-chair of the National Academy of Science (NAS) Committee on the State of U.S. Electronic Parts Radiation Testing Infrastructure for Space Applications, and was previously vice-chair and member of NAS committees on Achieving Science Goals with CubeSats and 3D Printing in Space, respectively. She serves on the NOAA Advisory Committee on Commercial Remote Sensing, and on the UN Committee on Space Research (COSPAR) to develop an international scientific roadmap for small satellites. She co-organizes a seminar series on space history and policy with the Smithsonian National Air and Space Museum. Before joining STPI, Dr. Lal was president of C-STPS LLC, a science and technology policy research and consulting firm. Prior to that, she was the Director of the Center for Science and Technology Policy Studies at Abt Associates, Inc.

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This document includes written and verbal statements prepared for the National Space Council's second meeting "Moon, Mars, and Worlds Beyond: Winning the Next Frontier" chaired by Vice President Mike Pence and hosted by NASA's Kennedy Space Center in Florida on Wednesday, February 21, 2018. The discussion included testimonials from leaders in the civil, commercial, and national security sectors about the importance of the United States' space enterprise. This publication presents some of the challenges the United States faces with regard to maintaining its international competitiveness in space, as well as some recommendations on how to retain its preeminence.

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