US Space Policies for the New Space Age: Competing on the Final Economic Frontier

Bruce Cahan, J.D. and Dr. Mir Sadat

based on Proceedings from

State of the Space Industrial Base 2020

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FOREWORD FROM THE U.S. DEPARTMENT OF COMMERCE

The ability to maintain competitive advantage in the global space economy requires all of the tools available to government and industry in a free-market system. Government activities - whether as a first adopter, a predictable customer or a regulator - will remain important, but private sector innovations, both technical and non-technical are the primary drivers of competitive advantage in our properly ambitious pursuit of space exploration and space commerce.

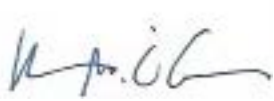
Like recent U.S. government policies, Bruce Cahan and Mir Sadat have recognized the even greater strategic dimensions of the new space race. While space has always been a key national security venue, the race is now shifted predominantly to an economic race with immensely important political and international consequences. The American ecosystem that is driving space exploration and space commerce must be encouraged and protected in a variety of ways: investment, advocacy, regulatory reform, and an improved, rigorous understanding of developments in the space economy. Further, beyond the natural roles of NASA, the Department of State, the Department of Defense, the Department of Transportation, and increasingly, the Department of Commerce, continuing emphasis should be placed on the roles that can be played by other U.S. economic, financial, and development organizations such as the Export-Import Bank, the Development Finance Corporation, Small Business Administration, and other entities from across the federal government.

Financial and insurance innovations must occur at the same exponential rate as the technical and business model developments that drive the space industry. As important risk-shifting mechanisms for a very broad and diverse American entrepreneurial base, new tools will be required to support the infrastructure and other longer-term support activities identified in this chapter. Innovative ideas for creating a space bank, use of tax credits, space bonds, and even a space commodities exchange, among others, merit careful consideration for inclusion into the U.S. toolkit for creating and sustaining advantage.

International space partnerships are an essential part of this strategic competition. While all countries are inspired by the idea and pursuit of space exploration, many are as a practical matter interested mostly in how to participate in the forthcoming trillion-dollar space economy from a workforce, industrial development, and economic growth perspective. Our long-standing space partnerships with Europe and Japan must now naturally begin to include a new slate of space partnerships with countries in Asia, Africa, and Latin America. The unique American advantage here, contrary to Chinese behavior, is genuine interest in helping with partner capacity and economic growth, and ensuring internationally accepted norms, rights, and values are upheld. The Artemis Accords, for example, reflect this collective interest in safe, responsible, and transparent exploration of the Moon. So does the growing international interest in private property rights in space.

The race for the 2060 space economy is on, and competition is not a detriment because it stimulates inventions and innovations that often benefit all of humanity. This is possible when it is fueled by adaptive U.S. government policies, strong private sector entrepreneurship, a strong finance and insurance ecosystem, an inspired and growing workforce, and effective partnerships. As the global partner of choice, the United States and its allies stand to prevail and maintain the lion's share in the economy. However, this race is much less about market share than it is about the norms, values, and behaviors that will carry us into the heavens to explore the Moon and other planets, and will create breath-taking new capabilities to improve our lives back on Earth for all of humanity.

We simply cannot fail in this race!



KEVIN M. O'CONNELL
Director, Office of Space Commerce
U.S. Department of Commerce

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The authors thank participants of the Space Industrial Base (SIB) 2020 Conference and Workshops, occurring between May 4 - 7, 2020, and hosted by New Space New Mexico (NSNM) and sponsored by the United States Space Force (USSF), the Defense Innovation Unit (DIU), and the United States Air Force Research Laboratory (AFRL). Over 120 space leaders from government, industry and academia who provided general observations, findings and recommendations during the main conference and associated working groups. Materials from the Conference are available online: https://newspacenm.org/state-of-space-agenda

In particular, the authors want to recognize participants of the SIB 2020 Conference's Space Policy and Finance Tools Working Group (WG) led by Mir Sadat, Pavneet Singh, and Katherine Koleski. The authors appreciate the insights shared by all WG participants (Appendix F) who may hold different views that those posited herein. The authors also thank Dr. Joel Mozer, Brigadier General Steven Butow, Colonel Eric Felt, and Dr. Tom Cooley for their insightful comments and inputs to earlier drafts of this Report.

The authors especially thank Kevin O'Connell for contributing his Foreward to this Report. As first Director of the Department of Commerce's Office of Space Commerce, his leadership set in motion bipartisan long-horizon thinking and support for policies that level the global playing field so American and allied space commerce can compete, play and thrive by a set of international norms, rules, and laws, even if other nations do not.

Finally, the authors express their appreciation to New Space New Mexico and specifically Casey DeRaad and Scott Maethner for their invaluable support in the review and publication of this Report.

While words can ably describe the future, visual narratives immerse the reader in it. After reading this Report, James Vaughan, a graphic illustrator of humanity's space futures, generously offered his artwork to begin each section of the Report to visualize current achievements and inspire innovative minds and policymakers to realize their dreams of that future. More of James' works is available at http://www.jamesvaughanphoto.com/.

This Report tells a story about how to ensure American strategic leadership and influence in space into the future – decades into the future. The Report's title was inspired by Gene Roddenberry's *Star Trek* themes, many focusing on dignity and diversity as humans pursue environmental sustainability, economic competition and scientific explorations. As a World War II bomber pilot and civil aviator, Roddenberry foresaw economic and social progress for all as the ultimate pathway to address injustice and ensure peace.

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CONFLICTS OF INTEREST STATEMENT

Bruce Cahan is the designer and principal organizer of the Space Commodities Exchange described in Section 10. Otherwise, the authors have no conflicts of interest regarding the material contained in this Report.

DISCLAIMER

The views expressed in this Report reflect those of the authors, as informed by conversations with State of the Space Industrial Base 2020 Workshop attendees, and do not necessarily represent the official policy or position of any Department or Agency of the US Government.

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Strategic Economic Competition

"When Henry Ford made cheap, reliable cars, people said, 'Nah, what's wrong with a horse?' That was a huge bet he made, and it worked."[1]

Elon Musk, CEO/Founder SpaceX

This report describes how to transform existing and emerging United States (US) space policies, legislation, and strategies into action plans that will ensure US strategic leadership in space for the 2040-2060 timeframe.

Space is the New Economic Center of Gravity

Historically, space was shared by nations pursuing peaceful commercial, environmental, humanitarian, scientific, and other activities with mutual respect and cooperation.[2] However, the era of renewed great power competition has evolved space also into a warfighting domain.[3] The convergence of commercial, civil, and national security interests transformed space into a center of gravity for the world's two competing economic systems. The United States leads in market-driven systems and democratic norms and values, and China and Russia lead in state-controlled systems with little regard to democracy.[4] This economic system dichotomy directly affects great power competition for the space economy in Earth orbit including low Earth orbit (LEO), cislunar orbit (between the Earth and the Moon), lunar orbit (around the Moon), and beyond.

Space as an Economic Frontier

The US Chamber of Commerce estimates that the global space market will increase from approximately $385 billion in 2020 to at least $1.5 trillion by 2040.[5] Rising economic benefits, national security importance, and advances in fundamental technologies also contribute to the growth in numbers and the improved capabilities of spacefaring nations. Advancements in commercial space technologies reduce costs and unlock new opportunities for economic growth and dual-use capabilities for ally and adversary spacefaring nations. The US government - previously the sole developer, producer and user of space technologies - has evolved into a major domestic and global customer in this growing New Space market.[6] Economic competition in space occurs at the intersections of centrally-planned, government-directed and free-market capitalization activities.

Competing Fully with China's Grand Strategy

China, Russia, and North Korea rely on centrally-planned and funded economic policies. China's One Belt and One Road Initiative (OBOR)[7] is its long-range plan for geopolitical and economic supremacy, spanning initially 64[8] and now 100[9] countries. Space infrastructure, from launch to satellite imagery and telecommunications, is now part of the OBOR Initiative. The Initiative aligns China's economic, industrial, and political assets for implementation and permanent financing.[10] Space and cyberspace components of the OBOR[11] Initiative are just the most visible parts of China's long-term

economic and national security commitments to dominate the emerging space economy.[12] Objectively, China is accomplishing impressive and formidable scientific and technical capacities in space, landing on the far side of the Moon, returning lunar materials to Earth, and planning other missions.[13]

Using All US Instruments and Tools of National Power

The US instruments of national power DIME: Diplomacy, Information, Military and Economic,[14] and increasingly FIL: Finance, Intelligence, and Law (Rule of Law)[15] and emerging S&T instruments: Science and Technology define and propagate a continuum of competition for national security and welfare.[16] The diversity of competing industries, interests, and freedoms are the hallmark of America's identity. They can provide consensus and support humanity's common cause in space.

US long-term planning and commitment in space is undermined by other great powers' attempts to weaken US strategic leadership in space and create schisms with allies and partners. As mentioned, China is executing its economic development plan for space (and global) dominance. In the 2020s, the United States must create and implement cohesive economic, financial, and policymaking plans to meet the challenge.

The United States should craft an enduring 2060 National Space Vision, better organize to advance interagency policies, and augment market-based economic activities. The United States can synthesize its broad and diverse technological base, ensure US global competitiveness, and leverage and protect ally and partner capabilities in a global marketplace consistent with US regulatory norms and free enterprise values. Sound fiscal, financial, and procurement policies can minimize market risk by supporting the financial infrastructure that is foundational to technological innovation. Realizing these opportunities requires an enduring economic and national security policy regime that promotes and incentivizes growth and innovation of the space industrial base in concert with trusted allies and partners. Such a policy regime will empower the various US government agencies to deploy the full range of government financial resources, procurement stimulus, and technical expertise to unleash the vibrant US commercial sector and shape prudent norms, rules, and behavior for a favorable order in space. Building up the multitrillion-dollar space economy will generate US domestic business opportunities, jobs, economic wealth, and economic development.

The domestic industrial base and its financial continuity will ensure interdependence and security for US allies and partners. It also provides independence from authoritarian regimes that might use space to control terrestrial and space economics, freedoms, and regional interests. US space policy must be agile in finding collaborations, while mitigating predatory practices. United States and global commercial space companies and their investors cannot be expected to navigate the technological risks of space, while major nation-states and their state-sponsored companies use predatory intelligence gathering and unfair intellectual property, pricing, terms, and other practices to dominate the still early phases of the space economy.

Renewed attention to national space policy and economic strategy presents opportunities to sustain and expand US national space power, enable whole-of-nation alignment, and attract new partnerships.

ENDNOTES

[1] "50 Innovation and Success Quotes from SpaceX Founder Elon Musk: Take a peek inside the mind of a genius with these success quotes from Elon Musk," Inc Magazine (March 8, 2016), https://www.inc.com/larry-kim/50-innovation-amp;-success-quotes-from-spacex-founder-elon-musk.html

[2] Five major United Nations Space Treaties (**UN Space Treaties**) set the international legal framework for activities in space, which Treaties are adopted and known as follows:

> 1967 – the **Outer Space Treaty**: United Nations General Assembly. "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies." UNOOSA: United Nations Office for Outer Space Affairs, http://www.unoosa.org/pdf/gares/ARES_21_2222E.pdf.
>
> 1968 – the **Rescue Agreement**: United Nations General Assembly. "Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space." UNOOSA. December 16, 1967. http://www.unoosa.org/pdf/gares/ARES_22_2345E.pdf.
>
> 1972 – the **Liability Convention**, United Nations General Assembly. "Convention on International Liability for Damage Caused by Space Objects." UNOOSA. November 29, 1971. http://www.unoosa.org/pdf/gares/ARES_26_2777E.pdf.
>
> 1976 – the **Registration Convention**, United Nations General Assembly. "Convention on Registration of Objects Launched into Outer Space." UNOOSA. November 12, 1974. http://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/registration-convention.html.
>
> 1984 – the **Moon Agreement**. United Nations General Assembly. "Agreement Governing the Activities of States on the Moon and Other Celestial Bodies." UNOOSA. December 5, 1979. http://www.unoosa.org/pdf/gares/ARES_34_68E.pdf.

The United States is a signatory to the first four UN Space Treaties but not the Moon Agreement. UNOOSA. "Status Of International Agreements Relating to Activities In Outer Space as at 1 January2020," https://www.unoosa.org/documents/pdf/spacelaw/treatystatus/TreatiesStatus-2020E.pdf

Due to commercial, national security, and civil aspects timelines shortening, bilateral international space agreements are negotiated and adopted to fill in basic legal framework principles, such as "The Artemis Accords: Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets and Asteroids for Peaceful Purposes," signed October 13, 2020 on behalf of Australia, Canada, Italy, Japan, Luxembourg, United Arab Emirates the United Kingdom and the United States, https://www.nasa.gov/specials/artemis-accords/img/Artemis-Accords-signed-13Oct2020.pdf.

[3] Forcherio, Joseph. "Great Power Competition: Let the Games Begin!" International Affairs Review, July 13, 2020, https://iar-gwu.org/2020/07/13/great-power-competition-let-the-games-begin/

[4] Few national economies are wholly market—driven or wholly state-controlled. Rather they are hybrids, trending toward one or the other as ideal in recognizing the primacy of wealth creation and control for the individual or the nation-state. The United States believes in and protects the best ideas that come from individual effort, ideas and the human dignity and passions to self-organize to create them, to convince investors through market transparency to safely fund them and to sell, trade and collaborate on the products and services readily available in the marketplace. China and Russia organize, fund, employ, and deploy state-owned control capital, assets, and ultimately people to achieve global market power.

[5] Higginbotham, Brian. "The Space Economy: An Industry Takes Off," US Chamber of Commerce, October 11, 2018, https://www.uschamber.com/series/above-the-fold/the-space-economy-industry-takes.

[6] White House National Space Council (**NSpC**). "A New Era for Deep Space Exploration and

Development" June 23, 2020, https://www.whitehouse.gov/wp-content/uploads/2020/07/A-New-Era-for-Space-Exploration-and-Development-07-23-2020.pdf (hereinafter, the "NSpC's Deep Space Vision.")

[7] OBOR is formally called the "Silk Road Economic Belt" and its counterpart is "21st Century Maritime Silk Road."

See Johnson, Christopher. President Xi Jinping's "Belt and Road" Initiative: A Practical Assessment of the Chinese Communist Party's Roadmap for China's Global Resurgence, Center for Strategic and International Studies, March 2016, https://www.csis.org/analysis/president-xi-jinping%E2%80%99s-belt-and-road-initiative.

[8] Chin, Helen and He, Winnie. The Belt and Road Initiative: 65 Countries and Beyond, Fung Business Intelligence Centre, May 2016, https://www.fbicgroup.com/sites/default/files/B&R_Initiative_65_Countries_and_Beyond.pdf.

[9] Organization for Economic Cooperation and Development. The Belt and Road Initiative in the global trade, investment and finance landscape, September 3, 2018, https://doi.org/10.1787/bus_fin_out-2018-6-en.

[10] State Council of the People's Republic of China. China Strengthens International Space Cooperation, April 19, 2018, http://english.www.gov.cn/state_council/ministries/2018/04/19/content_281476117420730.htm; State Council of the People's Republic of China, Outcome List of the Second Belt and Road Forum for International Cooperation (April 27, 2019), http://english.www.gov.cn/news/top_news/2019/04/28/content_281476632904666.htm

[11] Chase, Michael. "The Space and Cyberspace Components of Belt and Road Initiative," The National Bureau of Asian Research, September 2019, page 19, https://www.nbr.org/wp-content/uploads/pdfs/publications/sr80_securing_the_belt_and_road_sep2019.pdf

[12] Under this national economic plan, Chinese national and provincial governments provide funding and other support to its nascent commercial space sector. That support advances China's customer base for space launch, telecommunications, and other services at a scale and price point that market-driven firms in the United States cannot match.

[13] See highlights on page 33.

[14] Scott, Kevin D. April 25, 2018. "Strategy." Joint Chiefs of Staff - Joint Doctrine Note 1-18. https://www.jcs.mil/Portals/36/Documents/Doctrine/jdn_jg/jdn1_18.pdf?ver=2018-04-25-150439-540.

[15] Rodriguez, Cesar Augusto; Walton, Timothy C.;, and Chu, Hyong. "Putting the "FIL" into "DIME": Growing Joint Understanding of the Instruments of Power." April 1, 2020. Joint Force Quarterly Volume 97. https://apps.dtic.mil/sti/pdfs/AD1099537.pdf.

[16] O'Donohue, Daniel. June 3, 2019. "Competition Continuum." Joint Chiefs of Staff - Joint Doctrine Note 1-19. https://www.jcs.mil/Portals/36/Documents/Doctrine/jdn_jg/jdn1_19.pdf?ver=2019-06-10-113311-233.

PREFACE

Beyond Admiring the Problem

"The talent of the strategist is to identify the decisive point and to concentrate everything on it, removing forces from secondary fronts and ignoring lesser objectives."[17]

General Carl von Clausewitz, military theorist, 1780-1831

The United States can only become a space power with a diverse, robust, and innovative space industrial base that expands human and commercial activity and is a source of US national power.

To assess the impacts of commercial space offerings and foreign governments' pursuits of space capabilities on America's strategic leadership in space, this Report, "US Space Policies for the New Space Age: Competing on the Final Economic Frontier" supplements "State of the Space Industrial Base 2020" which was a joint publication of US Space Force (USSF), Defense Innovation (DIU), and Air Force Research Laboratory (AFRL),[18] which examined the state of the US space industrial base and identified the crucial national policies and required actions to fully employ all relevant instruments and tools of national power to ensure US space power.[19]

WINNING THE NEW SPACE RACE

THREAT: China eclipses the United States in space because of a long-term strategy, centrally-controlled economy and S&T rich workforce.

OPPORTUNITY: The United States crafts a long-term vision, fixes funding mechanisms and transparency to coordinate domestic stakeholders and attract international allies and investments in cultivating America's S&T workforce.

DESIRED RESULT: United States achieves political and financial economic alignment across the government, industry, academic and allies and partners to pursue an enduring strategic vision in Space.

"US Space Policies for the New Space Age: Competing on the Final Economic Frontier," hereafter known as "this Report," addresses key challenges; identifies specific threats, opportunities, and potential inflection points affecting the future of the space sector; recalls relevant and current historical precedents; and suggests the range of actions available to preserve and promote the healthy growth of civil, commercial, and national security space interests.

This Report focuses on the policy and finance areas centers of gravity in order for the United States to remain on top of this great power competition. Space and space-derived capabilities are vital for great powers in this competition. To execute the recently released 2020 *National Space Policy*,[20] the United States must adapt to increased space activities, the proliferation of spacefaring nations, dynamic changes globally in the commercial market, and exponential technological innovation in space capabilities and markets.

ENDNOTES

[17] Pietersen, Willie. “Von Clausewitz on War: Six Lessons for the Modern Strategist,” Columbia Business School, February 12, 2016, https://www8.gsb.columbia.edu/articles/ideas-work/von-clausewitz-war-six-lessons-modern-strategist

[18] Butow, Steven J.; Cooley, Thomas; Felt, Eric; and Mozer, Joel. “State Of The Space Industrial Base 2020: A Time for Action to Sustain US Economic & Military Leadership in Space.” July 2020, https://afresearchlab.com/news/state-of-the-space-industrial-base-2020-report/ (the **SIB 2020 Report**).

The SIB 2020 Report was the product of the SIB 2020 Conference and Workshops, held virtually between May 4 - 7, 2020, hosted by **New Space New Mexico (NSNM)** and sponsored by the **United States Space Force (USSF)**, the **Defense Innovation Unit (DIU),** and the **United States Air Force Research Laboratory (AFRL)**. Over 120 space leaders from government, industry and academia provided general observations, findings and recommendations during the May 2020 conference and associated working groups. Materials from the Conference are available online from NSNM: https://newspacenm.org/state-of-space-agenda

SIB 2020 Report was guided by previous reports and workshops, notably: Mozer, Joel, Air Force Space Command, Office of the Chief Scientist. “The Future Of Space 2060 & Implications For U.S. Strategy: Report on the Space Futures Workshop.” September 5, 2019, https://apps.dtic.mil/sti/pdfs/AD1101899.pdf; and Cooley, Thomas; Felt, Eric; and Butow, Steven J. “State of the Space Industrial Base: Threats, Challenges and Actions: A Workshop to Address Challenges and Threats to the U.S. Space Industrial Base and Space Dominance.” May 30, 2019, https://aerospace.csis.org/wp-content/uploads/2019/08/AFRL_DIU_Report_State_of_Space_Ind_Base_30May2019_Final.pdf.

[19] The SIB 2020 Report, to which this Report is a supplement, operationalizes space policies and strategies suggested by previous reports and studies. With heightened urgency, the SIB 2020 Report recommended the next levels of strategic analysis and required actions.

Like previous reports, the SIB 2020 Report represents the broad consensus of subject matter experts on what national actions are needed. However, committing the nation and its capital to implementing the SIB 2020 Report’s recommendations is in the hands of federal policymakers, Congress, and industry leadership. Government, private industry, and academic participants in the SIB 2020 Conference expect their recommendations will not fall on deaf ears. Previous space policy reports and forecasts had warned about the current tipping point US national security now faces within, to, and from space.

US interests and capabilities in space will be built over decades that transcend any Presidential four-year or Congressional two-year term. The SIB 2020 Report’s recommendations communicate objective bipartisan justifications to permanently pursue and assure reliable investments in national space goals and the establishment, maintenance, and enhancement of American assets and capabilities in space.

[20] United States. National Space Policy of the United States of America. Washington, DC: Executive Office of the President of the U.S., December 9, 2020, https:// https://www.whitehouse.gov/wp-content/uploads/2020/12/National-Space-Policy.pdf

SUMMARIZED FINDINGS AND POLICY RECOMMENDATIONS

Positioning the United States for Strategic Leadership in Space into 2060

"The United States must recognize that in the world of 2060, space will be a significant engine of national political, economic and military power for whichever nations or nation best recognize(s) the potential of space and organizes and operates to exploit and maximize that potential."[21]

Dr. Joel Mozer, USSF Chief Scientist, 2019

The following findings are categorized by traditional and emerging instruments of national power:

Diplomacy. The US government must continue to establish international standards, norms, and frameworks for creating peace, security, and wealth with likeminded allies and partners that share our common norms and values for the space economy and space exploration.

Military. The creation of the United States Space Force (USSF) was a critical first step to leverage and protect emerging space lines of commerce and civil exploration. The USSF must work closely with space industry entrepreneurs and innovators to advance dual-use technologies, streamline procurement processes, inspire their business models, and expand cooperation with National Aeronautics and Space Administration (NASA) and other civil space organizations. The USSF must coordinate the variety of Department of Defense (DoD)/Intelligence Community (IC) space stakeholders to simplify and forecast requirements through pooled procurement activities that serve the nation's national security needs in the immediate and long-term future.

Economics. The US government should leverage all US economic offensive and defensive tools to increase American commercial space activities and support the growth of US companies across the wide spectrum of the domestic space market and their international ventures.

Finance. The US government should take a forward-leaning posture to drive responsible financial engineering and innovation that anticipate the capital needs of the emerging space industry to grow the market infrastructure and funding base for the space economy over its near-term and longer-term time horizons.

Law, Information, and Intelligence. The US government must increase information sharing related to dual-use technological transfers, supply chain transparency, and counterespionage and counterintelligence diligence in the space sector. The government must engage in formal agreements with allies and partners on key areas of commercialization, intellectual property, and national security concern.

Science and Technology. The US commercial and government space workforce will need to fill more than 10,000 high-paying jobs by 2025.[22] The US government must support vocational, educational, and professional training

opportunities in science, technology, engineering, and mathematics (STEM) fields.

Missing elements of US space policymaking can be briefly summarized, as follows:

Missing Policy Element 1: Economic Policies for Winning in Space
US space economic policymaking is woefully inadequate to compete for global market share because China has cornered and dominated the global market. This Report recommends urgent economic development supplements to the 2020 *National Space Policy*. The United States policy must deploy and fully utilize existing public and private economic offensive and defensive tools across the full spectrum of the space market. The United States must also develop new market-enhancing tools to increase US commercial space activities, grow viable US space companies, and finance their growth.

Missing Policy Element 2: Interagency Coordinated Planning and Investing in Space
The US government does not have a national-level interagency executive agency for all-space matters. The government lacks timely interagency commitment to coordinate space policies, planning, budgeting, and program needs. Interagency space capabilities coordination, acquisition, and investment require a "whole-of-government" commitment to durable national policy on commercial space capabilities. There are many government and academic findings related to the importance of space in the future of US economic power and influence. There are numerous US government agencies that deal with space capabilities, planning, and acquisition as infrastructure. However, only NASA has a chief economist[23] to serve as a liaison between the benefits of a robust and agile commercial space sector, and the legacy procurement paths for bespoke government programs and missions. The Department of Defense (DoD) has one of the top three federal budgets but does not have a chief economist. The United States must recontextualize civil and national security acquisitions from the siloed bifocals of the Industrial Age to the economic lenses of the 2020 Digital Age in order to compete with and exit from great power competition with China and Russia.

Missing Policy Element 3: Declare and Finance Space as Critical Infrastructure
Commercial space operations support major portions of the US economy, national security, and US global competitiveness. Agriculture, banking, healthcare, insurance, telecommunications, transportation, and other industries designated as "critical infrastructure" increasingly rely on space-based capabilities to function and to coordinate with each other. By declaring commercial space as critical infrastructure, the full complement of US tools for growing, financing, protecting, and utilizing space-based capabilities can be

designed as multi-generational investments, built and expanded over successive Presidential Administrations.

Missing Policy Element 4: Sense of Urgency that 2020 is a Pivotal Moment for Space Economic Competitiveness

Global competitors and foreign adversaries are outpacing the United States in developing space programs. The United States remains at a strategic disadvantage because US procurement practices are complex, siloed, and opaque to the private sector. For example, DoD space programs, budgets, requirements, and acquisition processes remain largely unchanged since the Industrial Age of space as military domain. Government-procured space systems are historically characterized by high costs, long program schedules, and frequent delays due to risk aversion, funding gaps and limiting supplier access to technologies or government-centric technology requirements. US space companies face complex legal and regulatory requirements. For non-defense industrial base companies, the compliance requirements are overwhelming and exhaust resources of new entrants from collaborating on solutions for national security purposes.[24] Technological and procedural advances occurring in other economic sectors have yet to be applied to space programs. Entrenched procurement policies, practices, and beneficiaries limit the ability of the US government to leverage its market power to drive down costs, and send a clear and predictable demand signal to the private sector companies and investors.

ENDNOTES

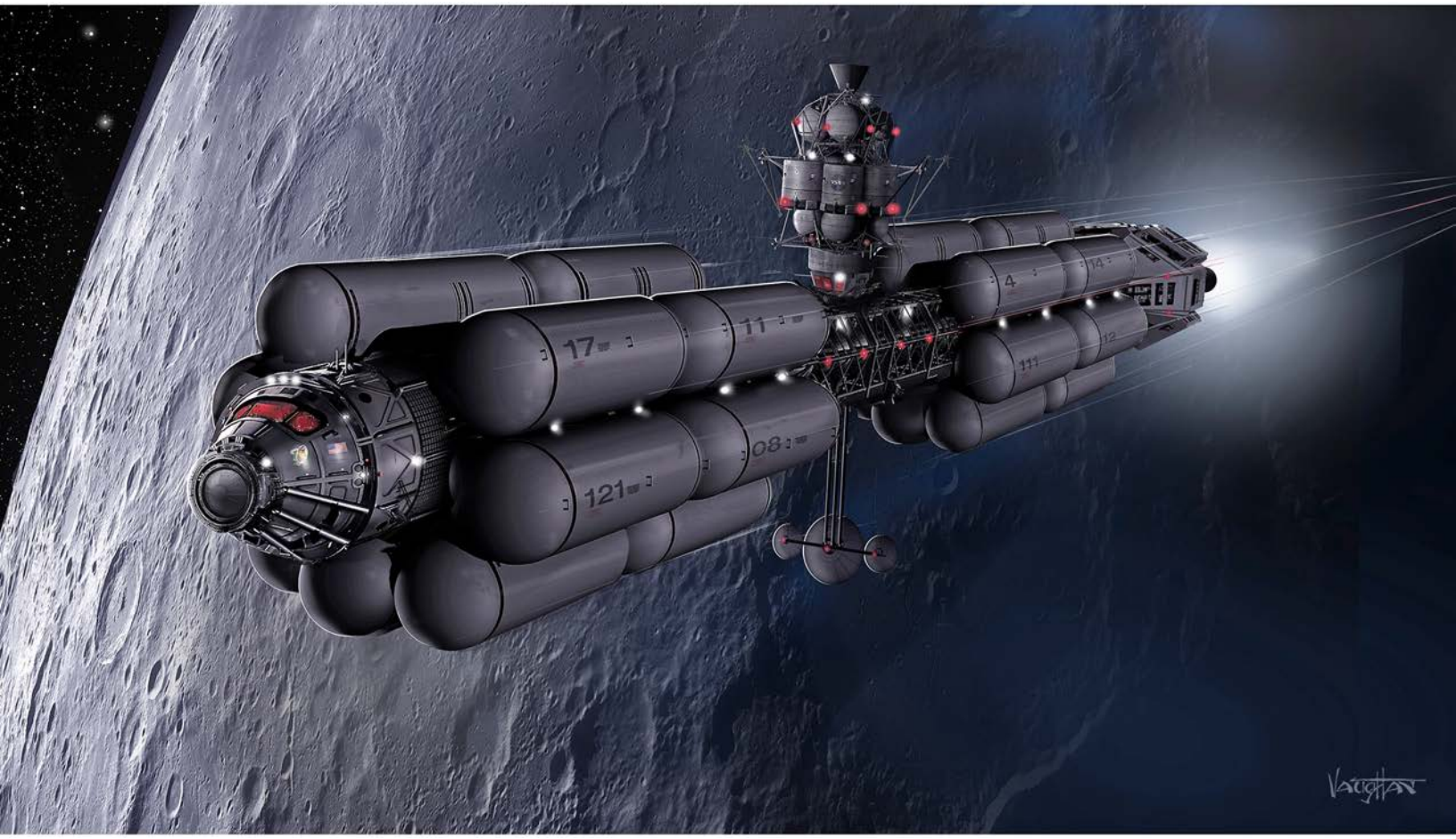
[21] Mozer, Joel. "The Future of Space 2060 and Implications for U.S. Strategy: Report on the Space Futures Workshop. Air Force Space Command," September 5, 2019. 1-32.

[22] SIB 2020 Report, fn. 18

[23] NASA, Office of the Administrator: Alexander MacDonald, Chief Economist, https://www.nasa.gov/about/alex-macdonald-chief-economist-office-of-the-administrator/.

By contrast, the Departments of States, Commerce, Transportation, and most other federal agencies all have or have had chief economists. US Department of Commerce. Office of the Chief Economist, Department Organizational Order DOO 35-7, November 22, 1994, https://www.osec.doc.gov/opog/dmp/doos/doo35_7.html, as superseded by Under Secretary for Economic Affairs, Department Organizational Order DOO 10-9, January 1, 2019, https://www.osec.doc.gov/opog/dmp/doos/doo10_9.html; US State Department, Office of the Chief Economist: Dr. Sharon Brown-Hruska, https://www.state.gov/bureaus-offices/under-secretary-for-economic-growth-energy-and-the-environment/office-of-the-chief-economist/; US Department of Transportation, Office of the Chief Economist Timothy Darren, https://www.transportation.gov/policy/office-chief-economist.

[24] Williams, Lauren. "Why Congress holds the key to DOD tech." FCW, February 6, 2020, https://fcw.com/articles/2020/02/06/dod-tech-randd-congress.aspx



1. INTRODUCTION

Organizing the Capacities that Open Unexplored Frontiers

"When a new frontier is opened, the new territory always looks vast, empty, hostile and unrewarding. It is always dangerous to go there and almost impossible to live there in loneliness and peril. The technological capacities of the time are always taxed to the utmost in dealing with the new environment. The explorations require huge investments of both public and private funds and the returns are always hazardous at first…The organization, capital and equipment required for the first exploratory efforts are so large that people tend at first to think only in terms of governmental and military actions; and only later do they conceive the new territory as simply an extension of their present territory and their present economy….an effort of prophetic imagination is what is required of us as citizens, so that we will not…leave the making of the future to others."[25]

Ralph J. Cordier, Chairman of General Electric Company, 1961

This Report highlights gaps in US space policymaking that national leaders must address. The 2017 *National Security Strategy* declares that "[s]upport for a vibrant domestic manufacturing sector, a solid defense industrial base and resilient supply chains is a national priority."[26] As compared to other domestic industrial base sectors, space is unique because overhead capabilities determine the adaptability, equity, and quality of US economic and social futures. Yet, the critical infrastructure of space and the companies building and operating it remain both underinvested in, and vulnerable to natural or intentional threats.

The Space Industrial Base Confronts the Great Power Competition

Space is a center of gravity for the world's two major competing economic and political systems. For far too long, US national security interests have discussed space as "critical infrastructure" but have yet to develop the economic, finance, and market structure improvements ***needed to grow the space industry as critical infrastructure***.

China's policies and practices are winning economically and China likely will overtake the US as the leading global economy within a decade.[27] China's economic strategies succeed, in part, because (i) they do things the United States will not (which is **not OK** so American leaders should object) and (ii) the United States is not doing the things needed to win this strategic economic competition (which is **not OK** so American leaders should change that). The "New Space Era" is defined by the emergence of affordable data discovery, availability, shareability and storage, artificial intelligence/machine

OTHER GREAT POWERS LEAD AS SPACE ASSET & SERVICE PROVIDERS

THREAT: Russia and/or China become the space leader providing lower-cost, higher capability space assets and service to United States allies and partners.

OPPORTUNITY: The United States commercial space providers increase capacity to source launch, imagery, and other space commodities to fulfill national security space requirements.

DESIRED RESULT: The playing field is leveled for US space companies to compete against state-owned or state-controlled companies funded by foreign adversaries and global competitors.

learning (AI/ML) cloud-based applications, small satellites (smallsats) and cubesats, cyber-secure data links and the means to launch, power, navigate, and control such assets to, in LEO, and beyond. New Space is a critical sector of the digital economy because it provides transparent real-time and archival terrestrial conditions and patterns, which also enhance the predictive analytics. Such capacity enables banks to arrange financing for more economic growth, insurers to price and settle insurance, suppliers to anticipate logistics disruptions, farmers to plant and harvest healthier crops, investors to allocate private capital across a broader portfolio of opportunities, and environmental and human rights groups to protect regional quality of life and sustainability.

The New Space sector is the center of gravity in the renewed great power competition between two primary economic philosophies. Chinese and Russian centrally-controlled economies view transparency and the United States as adversaries. America's economic heritage relies on market-driven economic systems built on regulations aimed at promoting transparency. US systems reflect "American entrepreneurial spirit," the belief that individual ingenuity and commitment grow private wealth, unleash national progress, and empower transparency for democratization and accountability of the public sector.

Whole-of-Government Support for Addressing Great Power Competition in Space

New Space requires agile and adaptive multi-dimensional, multi-sector, multi-purpose, and multi-generational space policymaking over the next decades. Long-term national space policymaking must align across government functions and agencies that depend on space capabilities to aim government's purchasing power at growing the commercial market and its financing, for budget efficiency and in the face of unbridled global competition.

Continued technologically feasible expansion in space activities and the proliferation and capabilities of ally and adversary spacefaring nations represent potential opportunities for international cooperation, threats, or a mix of both.

US efforts must focus on creating sustainable[28] space market subsectors with interdependent competing and cooperating supply chains, distributed decision-making, and diverse product and service offerings that interoperate through standards that enhance safety and security of space operations. This new focus should drive continuous innovation and increase capabilities at ever-lower costs through ongoing market competition, multiple entrant opportunities, and the diversification of investor and insurer risk.

Space policy must account for the rapid growth in United States and global commercial space subsectors. New Space must be protected from the predatory practices of foreign adversaries which use commercial space companies as state actor proxies.

The US government must harness the full range of US economic, financial, statutory, and intellectual property innovation and protection tools available to empower the US space industrial base and responsibly unleash space innovation.

Economics, Finance, and Insurance as Tools of National Industrial Readiness

US policymaking for space must include incentives that attract and justify patient, and affordable capital to finance relevant hardware-intensive technologies and also exponential technologies such as communications and software that build the space economy, its infrastructure, and innovative base. Policies must broadcast a robust market demand signal for space goods and services that anticipate the private sector's commercial activities and the government's needs.[29] Capital access is a critical requirement for a burgeoning new space industrial base in the United States. Recent advancements in commercial space reduce costs and unlock reinforcing new dual-use opportunities for economic growth and military capabilities.

The federal government must make a reliable long-term commitment to work with and support US commercial space companies. The government should leverage the price-performance advantages of commercial business models and their technologies.

The commitment must include whole-of-government procurement forecasts for space products and services. It must also finance and hold international companies to the same rules that US companies must observe. With a coordinated and persistent federal commitment to space, private investment in the US space industry may increase to grow a sustainable market-driven, private–public collaboration. US public-private collaboration and private capital would enable the US space industry to compete with state-controlled industries of global competitors such as China.

FINDING THE RIGHT NEEDLE IN A MOUNTAIN OF JUST RIGHT NEEDLES

THREAT: US adversaries collect and have more updated, better organized and shared knowledge of US space economy technology, talent recruitment, funding levels, and supply chains than is readily available as business intelligence to US companies. Fractured open and free trade system where knowledge, technology, talent, and capital are restricted from flowing out of and into the United States.

OPPORTUNITY: A private-public partnership resolves the disorganization of information that deny US companies, their investors and lenders, government agency program planners, and the commercial markets the required "business intelligence" presented in a coherent, updated, and accurate way to meet and overcome the risks of forming, pivoting and succeeding in global competition for slices of the space economy. America can reform US government and state regulations, mitigate uncertainty and costs to assets, products and services that US space companies want to sell or finance domestically and abroad.

DESIRED RESULT: Preserve US companies' competitive posture in space by harnessing all technological capabilities. Data science built on objective government and industry census and other data could provide this essential business intelligence to space entrepreneurs and their funders.

Historically, the United States has seized the opportunity to lead at the dawn of each new era of technological advance. America's commercial, government, and research leaders identified gaps in legacy economic, financial, and insurance tools to design and

manufacture commercial dual-use assets and capabilities for land, air, and sea domains. Legacy tools often did not and could not anticipate scenarios that US interests, companies and the military would face in the new era. Tools from the prior eras inspire and provide precedent and even statutory authority for tools required by the new era. Each new era of technology required government, industry, and academic leaders to create bold economic, financial, and insurance innovations through interagency bodies, public–private partnerships, and all market-driving byproducts that set up cascading waves of tipping point catalysts. During the Industrial Age, five months before the United States entered into World War II, President Franklin D. Roosevelt authorized the Economic Defense Board and Board of Economic Warfare.[30] During the Cold War, the DoD established the Office of Net Assessment led by Andrew Marshall.[31] Newer economic and market reforms followed, such as the DoD's Joint Capabilities Integration and Development System that aims to align the military's acquisition and procurement processes and systems.[32]

In the New Space Era, the terrestrial horizon and various strategic orbits must be scanned to ensure national security confidence in global supply chains, corporate entities, and nested investor identities. The United States must interpolate how others may acquire for benign purpose, or monopolize and weaponize for malicious intent, the assets, goods, services, and intellectual property developed or that supports any single or connecting networks of supply chains or technologies. US policy must consider how the international capital flows through their separately identified, pooled, and nested global structures and forms might further domestic or foreign aspirations.

The revival of the National Space Council (NSpC) in June 2017—after a hiatus of 25 years—restored an important institutional asset to guide national topline space policies across economic, national security and scientific exploration realms.[33] In February 2020, membership of the National Space Council expanded to include the Secretary of Energy, the Assistant to the President for Economic Policy and the Assistant to the President for Domestic Policy.[34] Since 2017, the NSpC, in coordination with the National Security Council (NSC) and the White House Office of Science and Technology Policy (OSTP), updated outdated portions of the 2010 *National Space Policy* culminating in a complete updated release of a *National Space Policy* in December 2020.[35]

Other examples of proactive commercial space policymaking include the National Oceanic and Atmospheric Administration (NOAA) revised regulations in May 2020 regarding the licensing of private remote sensing space systems,[36] based on the global availability of a given capability rather than on national security risk.[37] The Federal Aviation Administration (FAA) recently reorganized their space logistics support functions and expects to release final licensing and safety regulations for various types of launch and re-entry vehicles in Autumn 2020.[38] Such key steps update US regulations and policies to keep pace with rapid advancements in commercial space, at home and abroad.

The 2020 *National Space Policy* and supplemental separate policymaking efforts must drive a holistic space economy ecosystem that supports US national interests. US government space policies and strategies call for coherence and cooperation. However,

the nation has no integrated strategy that successfully aligns, tracks, and updates civil, commercial, and national security space strategic initiatives, procurements, and policymaking procedures to retain US strategic leadership and space dominance now or decades from now.

This Report highlights missing economic and financial elements of multi-generational strategic plans and associated national instruments and tools. Legacy gaps in the nation's *National Space Policy*, *National Space Strategy*[39] and *Defense Space Strategy*[40] have siloed business models and processes that (i) resist innovation, (ii) accentuate risk negation (without commensurate weighing of the risk of inaction), and (iii) wear out multi-disciplinary thinkers (polymaths) and their solutions, all of which siloes put at risk national security and economic competitiveness in space and on Earth.

This Report recommends filling such gaps, by calling for a comprehensive, integrative Space Vision, establishment of a National Space Task Force, and adaptation of historically proven economic and financial tools used previously in other industries for national security and commercial purposes.

ENDNOTES

[25] Cordiner, Ralph. "Competitive Private Enterprise in Space," Symposium on the Peacetime Uses of Space, University of California - Los Angeles, May 4, 1960, https://rjacobson.files.wordpress.com/2011/02/cordiner-article-1961.pdf

[26] United States. The National Security Strategy of the United States of America. Washington D.C: The White House. December 2017. https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf]

[27] World Bank. Purchasing Power Parities and the Size of World Economies: Results from the 2017 International Comparison Program. 2020. https://openknowledge.worldbank.org/bitstream/handle/10986/33623/9781464815300.pdf.

[28] As stated in the NSpC Deep Space Exploration Vision:

> "The term 'sustainable' can have different meanings, depending on the context. For example, financial sustainability is the ability to execute a program of work within budget levels that are realistic, managed effectively and likely to be available. Technical sustainability requires that operations are conducted repeatedly at acceptable levels of risk. Proper management of the inherent risks of deep space exploration and settlement is the key to making those risks "acceptable." Finally, policy sustainability means that the program's financial and technical factors are supportive of long-term national interests, broadly and consistently, over time. Robotic space exploration, for example, has benefited from a constancy of purpose driven by priorities identified by the National Academies through their Decadal Surveys. Similarly, the U.S. Armed Forces have supported scientific exploration and helped ensure the free flow of trade and commerce, while performing their fundamental mission of protecting the nation. Although the nation has healthy debates over the cost, size, capabilities and duties of our Armed Forces, it does not question whether the United States should maintain such forces. Long-term deep space exploration and development should seek to have a similar level of policy sustainability. It can do so by ensuring such efforts promote and strengthen the technical, economic and foreign policy objectives of the United States and its allies."

See the NSpC's Deep Space Vision, page 3, referenced in footnote 6.

[29] Transparent customer demand signals contribute to market efficiencies and courage private sector investment and lending, which in turn, accelerates sustainable industry growth through good and bad

economic cycles, and strengthens the reliability of the US industrial base companies.

[30] United States. “Establishing the Economic Defense Board,” Executive Order 8839, July 30, 1941, Washington, DC: Executive Office of the President of the U.S., https://www.presidency.ucsb.edu/documents/executive-order-8839-establishing-the-economic-defense-board; Stephens, Donald. “Organizing for Economic Defense: Henry Wallace and the Board of Economic Warfare's Foreign Policy Initiatives, 1942” Presidential Studies Quarterly, Vol. 26, No. 4, Intricacies of U.S. Foreign Policy (Fall, 1996), pp. 1126-1139, https://www.jstor.org/stable/27551675.

[31] DeCandido, Carl. “An Evolution of Department of Defense Planning, Programming and Budgeting System: from SecDef McNamara to VCJCS Owens,” US Army War College, June 4, 1996, https://www.hsdl.org/?view&did=447081; Schutte, John. “Casting Net Assessment: Andrew W. Marshall and the Epistemic Community of the Cold War” US Air Force Research Institute, November 21, 2017, https://media.defense.gov/2017/Nov/21/2001847253/-1/-1/0/DP_0016_SCHUTTE_CASTING_NET_ASSESSMENT.PDF.

[32] Chairman of the Joint Chief of Staff, Joint Capabilities Integration And Development System, January 23, 2015, https://www.mccdc.marines.mil/Portals/172/Docs/MCCDC/FDSP/FDS%20References/CJCSI%203170.01I.pdf?ver=2018-05-01-115226-050.

[33] United States. 82 FR 31429-Executive Order 13803 - Reviving the National Space Council. June 30, 2017, Office of the Federal Register, National Archives and Records Administration. https://www.federalregister.gov/documents/2017/07/07/2017-14378/reviving-the-national-space-council.

[34] Adding the Chair of the National Economic Council and the Director of the Domestic Policy signals greater support for the US space industrial base as a component of national security strategies for space. Adding the Department of Energy brings vital research, development, and intelligence capabilities to developing the space power for space exploration.

See United States. DCPD-202000074-Amending Executive Order 13803 – Reviving the National Space Council. Washington D.C: Office of the Federal Register, National Archives and Records Administration. 13 February 2020. https://www.federalregister.gov/documents/2020/02/20/2020-03556/amending-executive-order-13803reviving-the-national-space-council.

[35] United States. National Space Policy of the United States of America. Washington, DC: Executive Office of the President of the U.S., June 28, 2010, https://history.nasa.gov/national_space_policy_6-28-10.pdf; United States. National Space Policy of the United States of America. Washington, DC: Executive Office of the President of the U.S., December 9, 2020, https:// https://www.whitehouse.gov/wp-content/uploads/2020/12/National-Space-Policy.pdf

[36] United States. 84 FR 15296 - Streamlined Launch and Reentry Licensing Requirements. Washington D.C: Federal Register Online, National Archives and Records Administration. Retrieved from https://www.federalregister.gov/documents/2019/04/15/2019-05972/streamlined-launch-and-reentry-licensing-requirements; Marcia Smith, “FAA Shooting for September for Updated Commercial Space Launch Regulations.” Space Policy Online. June 23, 2020. Retrieved from https://spacepolicyonline.com/news/faa-shooting-for-september-for-updated-commercial-space-launch-regulations

[37] United States. 85 FR 30790 - Licensing of Private Remote Sensing Space Systems. Washington D.C: Federal Register Online, National Archives and Records Administration. Retrieved from https://www.federalregister.gov/documents/2020/05/20/2020-10703/licensing-of-private-remote-sensing-space-systems

[38] Montieth, Wayne. FAA Associate Administrator for Commercial Space Transportation, April 3, 2020, https://www.faa.gov/about/office_org/headquarters_offices/ast/media/AST_Update_Letter_April_2020.pdf ; Foust, Jeff. FAA commercial space office completes reorganization, SpaceNews, April 19, 2020, https://spacenews.com/faa-commercial-space-office-completes-reorganization/

[39] United States. National Space Strategy. Washington, DC: Executive Office of the President of the U.S., March 23, 2018, https://www.whitehouse.gov/briefings-statements/president-donald-j-trump-unveiling-america-first-national-space-strategy/.

[40] United States. Defense Space Strategy: Summary. Washington, D.C.: US Department of Defense, June 17, 2020, https://media.defense.gov/2020/Jun/17/2002317391/-1/-1/1/2020_DEFENSE_SPACE_STRATEGY_SUMMARY.PDF

2. CURRENT STATE

Addressing the Great Power Competition for Space Supremacy

"Great Power Competition in space is in some ways analogous to the Great Game of the 19th and early 20th centuries between Great Britain and Russia, which competed over access to resources and geostrategic positioning in Central and South Asia. Today, there is a similar great game brewing between China and other spacefaring nations led by the United States over access to potential cislunar resources and overall space dominance."[41]

Dr. Mir Sadat, NSC Policy Director, 2019

Great Power Competition For Space Dominance

During the Industrial Age, America's space policies focused on civil exploration and protection of national security information services. Policies were shaped by the need to preserve the United States' dominant position in an era of relatively limited commercial space activities and few competing spacefaring nations. US efforts in space were mission-focused and the government-controlled solutions, designs, implementations, and operations in a top-down fashion. Such missions, as with NASA's Space Shuttle program, locked in technical solutions for specific purposes for long periods of time. Once ended, the assets, capabilities, and operating costs of these technically-advanced 1960s – 2000s missions struggled to be repurposed as platforms for commercial business models or as parts of next-generation government programs.

Fast-forward to the 2010s. Over the last 20 years of the Digital Age, the US government has recognized space is a vital domain for enabling technologies that promote national power. The United States also recognized foreign challenges to US preeminence in space. While the Congressional Commission of 2000[42] and the Presidential Commission of 2002[43] took a holistic look at the issues and actions required, limited progress was made in implementing the Commissions' findings as national focus and priorities shifted to counterterrorism in the wake of the September 11, 2001 attacks. US space policies remained guided by a decade-old 2010 *National Space Policy* constructed at a time when space was considered a sanctuary domain, where the United States of America enjoyed unrivaled supremacy – until the recently released 2020 *National Space Policy* in the background of great power competition across all man-made and natural domains.[44]

Since 2017, the White House has reinvigorated space policymaking. In 2017, National Space Council (NSpC) was revived "to provide a coordinated process for developing and monitoring the implementation of national space policy and strategy."[45] The 2017 *National Security Strategy* calls for advancing space as a priority domain, promoting space commerce, and maintaining the United States' lead in space exploration.[46] The promulgated *2018 National Space Strategy* "emphasizes dynamic and cooperative interplay between the national security, commercial and civil space sectors."[47] Bipartisan support created the new USSF, renewal of the US Space Command, reimagining NASA's space programs, transferring space traffic management responsibility, and modernizing commercial space regulations. Released in June 2020, the *Defense Space Strategy* (DSS) relies on space infrastructure to assure the United

States' defense and military competitive advantage over nations who have an adversarial posture.[48] The *Space Capstone Publication* of the USSF contextualizes the importance of aligning civilian and military space activities and investments.[49] To enhance international cooperation on principled exploration of the Moon, Mars, comets and asteroids, in October 2020, NASA joined with seven other nations' space agencies to adopt the Artemis Accords.[50] Space traffic management has become – similar to the National Highway System's standards for safe and efficient transportation – a priority for federal and international policymaking and coordination.[51] In December 2020, the newly-released *National Space Policy* principally promotes private space industry, space rights and responsibilities, international cooperation, space sustainability, space relevance to national critical infrastructure, human activity in deep space, terrestrial benefits to humanity, space technologies, space services, and space operations.[52]

However, much work remains to integrate all US strategies and policies, as written and as implemented, so that they align across national security, commercial, and civilian space lines of effort. The United States must evolve to lead in a future operating environment where more state and non-state actors increase space activities. US policymaking must adapt holistically to keep up with the rapid pace of change in space.

China's Adversarial Space Economics and Industrial Policy

A decade ago, China laid out a 30-year cislunar economic and industrial plan. China's planned Belt and Road Initiative, Space Information Corridor, and Digital Silk Road will supposedly generate $10 trillion - in Chinese Yuan - by 2050 through a tax-advantaged Special Overseas Economic Zone between the Earth and the Moon and numerous investment, tax, state-owned company, and other military and civilian strategies.[53] Ten trillion dollars for China dwarfs estimates of the US portion of the space economy at $1.5 trillion by 2040 (pre-COVID-19 estimation).[54] China's efforts embolden US near-peer competitors who are also enhancing their investments in space and seeking strategic acquisitions of US companies, as well as US talent and their intellectual property, to advance their capabilities. Such acquisitions erode the investment and market potential of distressed US firms facing fundraising or revenue gaps, and transfer their intellectual property and talent to foreign ownership or influence.

China's institution building and use of space are the key providers of global economic development reinforcing their 5G internet and Belt and Road Initiative, whereby infrastructure for economic development wins over and binds new allies and partners. China's military–civil fusion industrial development and similar policies are also perceived to undermine America's traditional leadership role and create schisms between the United States and its ally and partner spacefaring nations. [55]

To compete with China, the United States cannot become China. Instead, the United States must play to its strengths to retain the global competitive advantage. The United States must utilize its soft power as global leader in financial and technological innovation, proponent of vibrant true market economies and, most importantly, democratic norms and values. The United States must provide a level-playing field advantage to allies, partners, and other nations that view the United States as the

leading model of open, transparent economic and financial markets - which stand in contrast with the Chinese state-controlled opaque model.

China was a late entrant to the space race. Its first satellite was sent into orbit in 1970,[56] by which time the United States had already landed astronauts on the Moon. In 2003, more than 40 years after the Russians and Americans embarked on the space race, China sent its first astronaut into orbit.[57] In 2007, China conducted a kinetic anti-satellite (ASAT) test on its dead weather satellite, which created a debris field of almost 3,400 fragments, more than half of which are expected to be in orbit in 2027.[58]

Fast forward to 2018, when China conducted more space-oriented operations than any other country. In 2019, China became the first nation to send an unmanned rover to the moon's far side.[59] In June 2020, China launched the BeiDou system, which is an alternative to global positioning system (GPS) space-based navigation and timing, to become the largest space-based position and timing system in the world – not only removing China's dependence on US' GPS but also serving as means to lure the rest of the world to adopt and provide data on its movements via BeiDou.[60] In July 2020, China sent its first unmanned mission to orbit Mars before landing a rover on the surface, and is expected to reach the red planet in February 2021.[61] In December 2020, China landed on the Moon, planted their flag, collected Moon rock samples, and returned to Earth.[62] Chinese plans also include launching a permanent space station by 2022, and sending astronauts to the Moon by the 2030s.[63] If successful, China would become only the second country, after the United States, to put a citizen on the Moon.

While the past twenty years of Chinese space accomplishments are impressively vast and rapid, their acquisition, data harvesting and exploitation of human knowledge and talent, product designs and manufacturing methods, prototypes and plans from US and allies' companies, research facilities, universities and government operations has provided intellectual property, trade secrets and other assets that China did not discover or fund on its own.

Today, China's commercial space sector is in its infancy but is set to grow with continued national and provincial support, which have been rapidly increasing over the past three years.[64] Since 2004, the United States and China accounted for 74% of the $135.2 billion venture capital (VC) invested in commercial space. [65] The early 2020s are pivotal, as it would be far cheaper for China and Chinese commercial space firms to acquire space technologies from the United States or allied nation companies seeking revenues or facing cashflow constraints, than to build the companies and their teams and technologies from scratch in China. The tight coupling of Chinese military goals and an economy organized to achieve those goals magnifies the economic threats and market disruptions that the United States must immediately address, in order for DoD and national security operations to rely on US commercial space capabilities.

ENDNOTES

[41] Sadat, Mir. "Space Cooperation in an Age of Great Power Competition in the Indo-Pacific." Hudson Institute. 2019. https://www.youtube.com/watch?v=63B74CEbpsg

[42] United States. The Commission to Assess United States National Security Space Management and Organization. Public Law 106-65, the National Defense Authorization Act for Fiscal Year 2000, Section 1622. Washington, DC: US Congress, https://www.congress.gov

[43] United States. Final Report of The Commission On The Future Of The United States Aerospace Industry. Washington: Commission on the Future of the United States Aerospace Industry, November 2002, https://history.nasa.gov/AeroCommissionFinalReport.pdf

[44] United States. National Space Policy of the United States of America. Washington, DC: Executive Office of the President of the U.S., June 28, 2010, https://history.nasa.gov/national_space_policy_6-28-10.pdf; ; United States. National Space Policy of the United States of America. Washington, DC: Executive Office of the President of the U.S., December 9, 2020, https:// https://www.whitehouse.gov/wp-content/uploads/2020/12/National-Space-Policy.pdf.

[45] United States. P82 FR 31429 - Reviving the National Space Council. Washington D.C: Office of the Federal Register, National Archives and Records Administration. 20 August 2019. https://www.govinfo.gov/content/pkg/FR-2017-07-07/html/2017-14378.htm

[46] United States. The National Security Strategy of the United States of America. Washington: Executive Office of the President of the U.S., 2017. https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf.

[47] Smith, Marcia. “White House Releases Fact Sheet On New National Space Strategy” SpacePolicyOnline.com. March 24 2018. https://spacepolicyonline.com/news/white-house-releases-fact-sheet-on-new-national-space-strategy/

[48] The DSS focuses on four lines of effort: 1) build a comprehensive military advantage in space; 2) integrate space into national, joint and combined operations; 3) shape the strategic environment; 4) cooperate with allies, partners, industry and other US government departments and agencies. See, US Department of Defense. “Defense Space Strategy: Summary,” https://media.defense.gov/2020/Jun/17/2002317391/-1/-1/1/2020_DEFENSE_SPACE_STRATEGY_SUMMARY.PDF

[49] Raymond, John W. “Space Capstone Publication: Spacepower” June 2020. https://www.spaceforce.mil/Portals/1/Space%20Capstone%20Publication_10%20Aug%202020.pdf.

[50] “The Artemis Accords Principles For Cooperation In The Civil Exploration And Use Of The Moon, Mars, Comets, And Asteroids for Peaceful Purposes.” October 13, 2020, https://www.nasa.gov/specials/artemis-accords/img/Artemis-Accords-signed-13Oct2020.pdf.

[51] Dominquez, Michael; Faga, Michael; Fountain, Jane; Kennedy, Patrick; and O’Keefe, Sean. “Space Traffic Management: Assessment of the Feasibility, Expected Effectiveness, and Funding Implications of a Transfer of Space Traffic Management Functions.” NAPA: National Academy of Public Administration. August 2020, https://www.napawash.org/uploads/NAPA_OSC_Final_Report.pdf.

[52] United States. National Space Policy of the United States of America. Washington, DC: Executive Office of the President of the U.S., December 9, 2020, https:// https://www.whitehouse.gov/wp-content/uploads/2020/12/National-Space-Policy.pdf.

[53] Chase, Michael. “The Space and Cyberspace Components of the Belt and Road Initiative,” National Bureau of Asian Research, No. 80 (September 2019). https://www.nbr.org/wp-content/uploads/pdfs/publications/sr80_securing_the_belt_and_road_sep2019.pdf; “China Proposes Establishing Moon-Based Special Economic Zone.” China Briefing (November 8, 2019), https://www.china-briefing.com/news/china-proposes-establishing-moon-based-special-economic-zone/; Jones andrew. “From a farside first to cislunar dominance? China appears to want to establish ‘space economic zone’ worth trillions,” (Space News – February 15, 2020), https://spacenews.com/from-a-farside-first-to-cislunar-dominance-china-appears-to-want-to-establish-space-economic-zone-worth-trillions/.

Throughout this Report, China's or other foreign nation's space activities are stated in US Dollars (USD$) to ease comparing the scale and timeframe of such activities' impacts to those conducted in USD$ in the US or elsewhere. The reader should bear in mind that China or other nation's space activities will be conducted in their fiat currency – Yuan or Renminbi in the case of China – thereby strengthening the global reach and demand for currencies and investments, loans, contracts, and financial derivatives denominated in their fiat currency and thus growing that nation's monetary policy, power, and reach into global financial markets and investment portfolios.

[54] Higginbotham, Brian. "The Space Economy: An Industry Takes Off," US Chamber of Commerce, October 11, 2018, https://www.uschamber.com/series/above-the-fold/the-space-economy-industry-takes.

[55] The United States must recognize how China's policies promote its space ambitions through military and economic channels. See, Stokes, Mark et al, "China's Space and Counterspace Capabilities and Activities," Prepared for: The U.S.-China Economic and Security Review Commission (March 30, 2020), https://www.uscc.gov/sites/default/files/2020-05/China_Space_and_Counterspace_Activities.pdf.

[56] Defense Intelligence Agency. "Challenges to Security in Space." January 2019, page 13, https://www.dia.mil/Portals/27/Documents/News/Military%20Power%20Publications/Space_Threat_V14_020119_sm.pdf.

[57] Ibid, page 18.

[58] The United States tracks all space debris, and ironically when any of 2007 ASAT debris potentially interferes with Chinese satellites, it is the United States military than warns the Chinese of that fact.

See Sadat, Mir. "Great Power Competition in Space." Potomac Institute, June 2019, https://www.terrorismelectronicjournal.org/app/download/9285322982/Dr+Mir+Sadat+Edited+Transcript+5.14.19.pdf?t=1560178085.

[59] Office Of The Secretary Of Defense. "2020 Annual Report to Congress: Military and Security Developments Involving the People's Republic of China." January 2002, page 64, https://media.defense.gov/2020/Sep/01/2002488689/-1/-1/1/2020-DOD-CHINA-MILITARY-POWER-REPORT-FINAL.PDF.

[60] Tsunashmma, Toru. "In 165 countries, China's Beidou eclipses American GPS: Beijing extends its data reach into space and sea." Nikkei Asia, November 25, 2020, https://asia.nikkei.com/Spotlight/Century-of-Data/In-165-countries-China-s-Beidou-eclipses-American-GPS.

[61] Jones, Andrew. "China chooses landing site for its Tianwen-1 Mars rover: The rover will touch down inside the huge impact basin Utopia Planitia." Space.com, October 28, 2020, https://www.space.com/china-mars-rover-tianwen-1-landing-site.

[62] Myers, Steven Lee and Chang, Kenneth. "China Brings Moon Rocks to Earth, and a New Era of Competition to Space: The Chang'e-5 mission's success highlights the progress of China's space program, and growing rivalry with the United States." New York Times, December 16, 2020, https://www.nytimes.com/2020/12/16/science/china-moon-mission-rocks.html.

[63] Westcott, Ben; Rivers, Matt; and Lee, Lily. "50 years after US moon landing, China is catching up in the space race." CNN.com, July 19, 2019, https://www.cnn.com/2019/07/19/asia/china-apollo-us-space-race-intl-hnk/index.html.

[64] Irina Liu, Evan Linck, Bhavya Lal, Keith W. Crane, Xueying Han and Thomas J. Colvin. "Evaluation of China's Commercial Space Sector ," IDA Science & Technology Policy Institute, September 2019, https://www.ida.org/-/media/feature/publications/e/ev/evaluation-of-chinas-commercial-space-sector/d-10873.ashx.

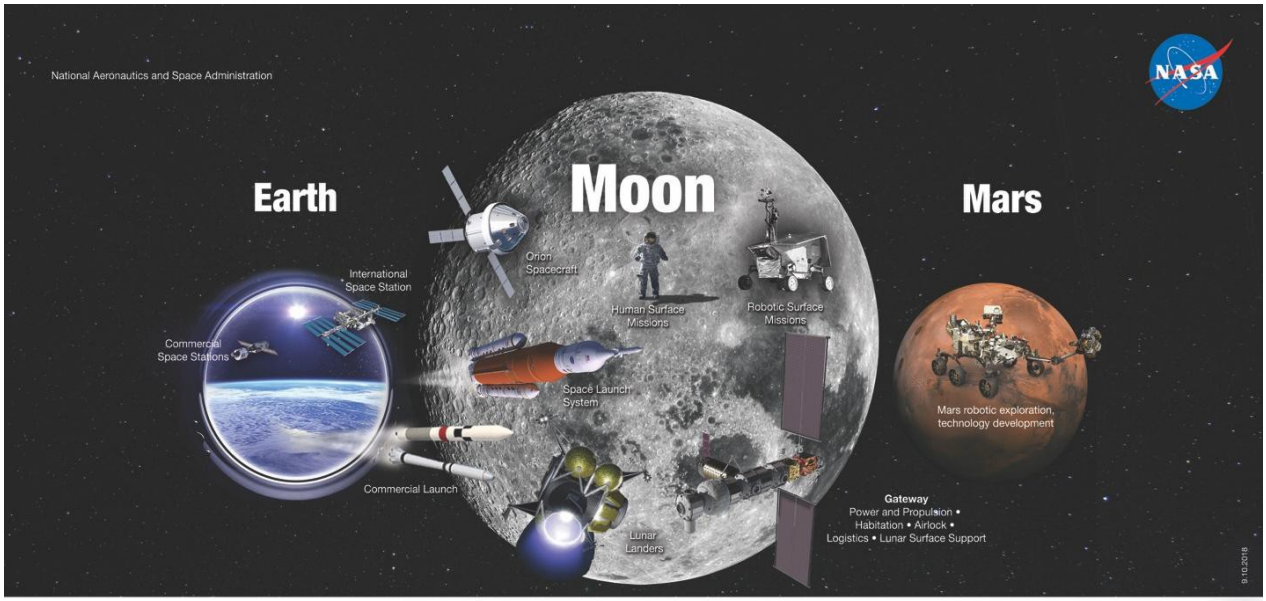
[65] Space Capital 2020. Space Investment Quarterly. Q2 2020, https://www.spacecapital.com/publications/space-investmen-quarterly-q2-2020.

3. ISSUES AND CHALLENGES

Addressing Great Power Competition in the Future Space Domain

"We need to do things differently, moving on from a joint force to an integrated force, with every asset and capability we have, seamlessly, in real time, with our partners and allies, to hold our adversaries to risk … That requires a rebalancing from Industrial Age to Information Age capabilities – investing in cyber, space, electronic warfare, AI robotics and autonomy – coupled with the best of what already exists … That means asking ourselves what the air and space environment of 2030, 2040 or even 2050 will look like."[66]

Ben Wallace, Defence Secretary, United Kingdom, 2020



America Will Lead
Fly Astronauts on American Spacecraft
Develop New Commercial Space Stations

America Will Lead
Fly Astronauts Around the Moon
Establish First Human Outpost on Moon for a Sustained Campaign of Exploration & Utilization

America Will Lead
Return the First Scientific Collection from Mars
Practice Round-Trip Leading to Humans on Mars

Peaceful Uses of Space and Space Exploration

Space has been primarily a shared, not a warfighting, domain.[67] With each passing second of Planck time,[68] space enables a modern way of life, provides instantaneous global imagery, assures telecommunications, and captures humanity's imagination for civil space exploration. As a result, space is a burgeoning marketplace and territory for commercial ventures and investors. Strengthening the US commercial space industrial base is vital to and beyond US national security.

Civil space activities are a source of US "soft power" in global commerce, cooperation, and investment.[69] The civil space sector, led by NASA, is fundamental to America's national security.[70] NASA is on an ambitious critical path to return to the Moon by 2024,[71] along with developing the capabilities and infrastructure for a sustained lunar presence. NASA's lunar plans provide a lunar staging area for missions to Mars and

beyond. They offer a strategic and economic presence for the United States on the Moon.

Congress, the White House, DoD, and NASA must recognize that economic and strategic dominance in service of national security requires catalyzing and accelerating growth of a vibrant, private US industrial and cultural expansion into the Solar System.

Human visitation and eventual settlement beyond the Earth require sustaining visionary leaders, aided by, and aiding, US national security. A recurring theme in US policy is "maintaining and advancing United States dominance and strategic leadership in space" because US global competitors and adversaries are competent and capable of outpacing American space capabilities.[72] The stakes are high: At this historic moment, there is a real race for dominance over cislunar access and resources.

Regulations Should Foster US Commercial Space as a National Asset

Leveraging the reimagination and disruption of terrestrial industries, the US commercial space industry is pushing the frontiers of the United States and global space economics and capabilities. A pre-COVID19 assessment by the US Chamber of Commerce projected that the US space market will increase from approximately $385 billion in 2020, to at least $1.5 trillion by 2040.[73] This projection represents a seven percent (7%) annual compound average growth rate (CAGR), driven largely by expanded business opportunities in Low Earth Orbit (LEO). Total addressable market (TAM) for US commercial space companies could be far larger were they to have federal and financial support for initiating cislunar space operations and opportunities.

Recent advancements in commercial space technologies and business models have driven down costs and unlocked new areas of economic growth and space capabilities that outpace and de-risk acquiring capabilities through traditional US government economic development, research and development (R&D), procurement and regulatory policies and processes. **US regulations must ensure that US companies lead in commercial space**. In specific, technological advances that lower access costs and expand space mission capabilities, content, continuity, and redundancies must be fully supported by or incorporated into US government programs, budgets, requirements, and acquisition processes. Until commercial space offerings are fully incorporated, and federal acquisition policies and personnel commit to innovation, US government fiscal buying power, intelligence and program support will lag and remain inadequate in comparison to US private sector companies and the nation's global competitors and adversaries in space.

Addressing COVID-19's Impact on US Commercial Space

The COVID-19 pandemic damaged and still challenges the US space industrial base. US domestic investors' funding of space R&D remains inconsistent across the lifecycle of New Space companies and the spectrum of technologies necessary to grow the space economy. To date, public R&D, government procurements and visionary space entrepreneurs have played a major role in establishing and funding the New Space industrial base. In the last five years, $11 billion of private capital has been invested.[74]

COVID-19 AND THE SPACE ECONOMY

THREAT: Economic recession following the COVID-19 pandemic limits the ability of the United States, other governments, and venture capital to support the space industry.

OPPORTUNITY: The space economy needs increased United States investments to weather the current recession.

DESIRED RESULT: United States companies whose teams are the "human capital" our nation needs to dominate and thrive in the space economy over the longer term.

Traditional private investors may become reluctant to fund space technologies due to perceptions of higher risk over longer time horizons before receiving profitable returns on their capital. Institutional and long-horizon investors who manage patient capital have an appetite for illiquid, but higher yielding, terrestrial alternative asset investments such as commodities, private equity limited partnerships and real estate.[75]

The COVID-19 pandemic has created economic uncertainties making the New Space's funding model unreliable. COVID-19 significantly impacted venture capital (VC)-backed companies: the pace of VC space investments fell 85% between April - June, as compared to January – March, in 2020.[76] Pre-COVID-19, the New Space industrial base confronted multiple challenges in raising later stages of venture capital such as (1) the lag between having an early-stage startup with an idea and commercializing a viable revenue-generating product, (2) the lack of market liquidity for founder and private equity space investments to attract and retain talented teams, and (3) the lack of a market to re-sell contracts for space goods and services when customers buy more capacity than needed.

Even prior to the COVID-19 pandemic, federal financing of US R&D was at a historically minor level, as compared to businesses and universities.[77] US government support for basic research has steadily declined as a percent of GDP. The federal government will experience near- to medium-term budget constraints.[78] The vibrant venture community in the United States has taken up a portion of this slack by increasing R&D investment in later-stage and applied research. However, founding teams and VC financing rely on government to fund earlier R&D for basic science and engineering. Therefore, government must resume the sustainable and impactful past levels of support for basic research, an essential role in the space economy's public-private partnership that ensures US leadership in space.

Space as Existential Terrain for National Security

In this Digital Era, space integrates and drives all elements of US national security. The Cold War may be over, but since the early 2010s, a renewed era of great power competition has emerged across terrestrial land, air, sea, and cyber domains. This competition extends into space, where a great game ensues.[79] Space is no longer an uncontested or sanctuary domain. Competent and capable global competitors and peer adversaries are challenging US military, commercial, and civil space interests. The United States, along with its allies and partners, has had to accept and anticipate that space may be a warfighting domain, as suggested primarily by Russian and Chinese counter-space capabilities, military operations, and declarative statements.

INTENTIONAL OR NATURAL DAMAGE TO SPACE ASSETS OR SERVICES

THREAT: A nation-state or non-state actor hacks existing space assets resulting in debris, technical glitches, and financial damage.

OPPORTUNITY: United States companies' assets and the services they provide must develop cybersecurity standards for space and create sufficient insurance to rebuild any threatened or damaged space assets.

DESIRED RESULT: A significant fraction of new space company's satellites will follow strict self-imposed cybersecurity standards for space and also carry insurance to cover planned or accidental damage in space.

On December 20, 2019, the bipartisan National Defense Authorization Act (NDAA) for Fiscal Year 2020[80] authorized the creation of the US Space Force, under the Department of the Air Force, to secure US national interests in an increasingly contested domain.[81]

Back in October 1775, the Continental Congress established the US Navy to ensure that commercial and government fleets could freely navigate the Atlantic coastline - today, that includes the South China Sea. Likewise, the USSF's mission is to ensure unfettered access to and the freedom to operate in space. The 2017 *National Security Strategy* considers space to be a "priority domain."[82] Freedom of navigation is a sovereign right that nations have fought to achieve and defend.[83] The USSF's main role is to organize, train and equip, as well as to protecting US space interests and supporting terrestrial and joint warfighters (e.g., US Space Command). Thus, USSF must secure US national interests in space, whether military, commercial, scientific, civil, or enhancing US competitiveness for cislunar leadership.

Integrating Government Stakeholders, Policies, and Practices to Grow Space Capabilities

The United States needs a bipartisan multi-administration space policy, coupled with enabling financial tools, to ensure US national power by growing America's space industrial and innovation base. Required is innovative thinking to implement visionary space policies enabling whole-of-nation alignment and attract new partners to promote US interests and economic values. The United States can synthesize a broad and diverse technological base, align mission requirements for US programs that depend on space, ensure US global competitiveness, reduce over-dependence on foreign space

capabilities suppliers, and leverage and protect ally and partner capabilities in a global marketplace.

Sound fiscal and acquisition policies can expand the range of interoperable space-based capabilities available to government functions at reduced obsolescence and lifecycle costs. These policies can minimize the market risk of limited supply or over-dependence in a single contractor, support the infrastructure foundational to commercial space technological innovation, and ensure US government actions promote US competitiveness in a global market.

Realizing the benefits of a 2060 National Space Vision requires an enduring economic and national security policy regime that promotes and incentivizes growth and innovation of the space industrial base in concert with trusted allies and partners. Such a policy regime empowers federal agencies to deploy the full range of government financial resources and technical expertise needed over the long term to responsibly unleash the vibrant US commercial sector and shape prudent norms, rules, and behavior for a level playing field in space.

ENDNOTES

[66] Wallace, Ben. "Defence Secretary Ben Wallace gives a speech at the Air and Space Power Conference." The Air & Space Power Association: United Kingdom. 15 July 2020. https://www.gov.uk/government/speeches/defence-secretary-ben-wallace-gives-a-speech-at-the-air-and-space-power-conference

[67] See UN Space Treaties at footnote 2.

[68] Summons, Dan. "What is Planck length? What is Planck time?" PhysLink Physics and Astronomy Online, https://www.physlink.com/education/askexperts/ae281.cfm; Energy Wave Theory. "Planck Time," 2020, https://energywavetheory.com/physics-constants/planck-time/

[69] Sabathierand, Vincent G. and Faith, G.Ryan. "Smart Power Through Space." Center for Strategic and International Studies (CSIS) International Space Exploration Update 2008. https://csis-website-prod.s3.amazonaws.com/s3fs-public/legacy_files/files/media/csis/pubs/080220_smart_power_through_space.pdf; USC Center for Public Diplomacy. "The Soft Power 30: A Global Ranking of Soft Power 2019." October 2019, https://softpower30.com/wp-content/uploads/2019/10/The-Soft-Power-30-Report-2019-1.pdf

[70] NASA Artemis Accord, https://www.nasa.gov/specials/artemis-accords/index.html; United States. Compilation of Presidential Documents. 85 FR 20381 - Encouraging International Support for the Recovery and Use of Space Resources. Washington D.C: Office of the Federal Register, National Archives and Records Administration. 6 April 2020, https://www.govinfo.gov/content/pkg/FR-2020-04-10/html/2020-07800.htm

[71] While a lunar landing again is important, what is more important is readiness and capability to permanently stay on the Moon to develop space mining, space tourism, orbiting space bases, refueling stations and the means to get to Mars. NASA and DoD should provide more precise assessments as to when they expect human settlements on the Moon. That date should supersede any other previous dates and drive any other subsequent dates.

Image taken from "National Space Exploration Campaign Report Pursuant to Section 432(b) of the NASA Transition Authorization Act of 2017 (P.L. 115-10) September 2018" https://www.nasa.gov/sites/default/files/atoms/files/nationalspaceexplorationcampaign.pdf

[72] United States. DCPD-201900558-National Security Presidential Memorandum on the Launch of

Spacecraft Containing Space Nuclear Systems. Washington D.C: Office of the Federal Register, National Archives and Records Administration. 20 August 2019. https://www.govinfo.gov/app/details/DCPD-201900558

[73] Higginbotham, Brian. “The Space Economy: An Industry Takes Off,” US Chamber of Commerce, 2018, https://www.uschamber.com/series/above-the-fold/the-space-economy-industry-takes

[74] Chris Quilty and Justin Cadman. “Recession Impact on Venture Space Ecosystem,” April 20, 2020, https://www.quiltyanalytics.com/wp-content/uploads/2020-0420-Venture-Space-Investing-Report-Page1.pdf.

[75] PwC. (2015) “Alternative asset management 2020: Fast forward to centre stage.” https://www.pwc.com/jg/en/publications/alternative-asset-management-2020.pdf; Preqin. (2020) “Alternatives in 2020,” https://docs.preqin.com/reports/Preqin-Alternatives-in-2020-Report.pdf; J.P. Morgan Asset Management. (2020) “2020 Global Alternatives Outlook,” https://am.jpmorgan.com/content/dam/jpm-am-aem/emea/regional/en/insights/portfolio-insights/global-alternatives-outlook-ce-en.pdf.

[76] Space Capital 2020, Space Investment Quarterly - Q2 2020, https://www.spacecapital.com/publications/space-investment-quarterly-q2-2020

[77] NSF: National Science Foundation. (January 2020). “The State of U.S. Science and Engineering 2020: U.S. R&D Performance and Funding,” https://ncses.nsf.gov/pubs/nsb20201/u-s-r-d-performance-and-funding.

[78] Congressional Budget Office. “10-Year and Long-Term Budget Projections – September 2020,” https://www.cbo.gov/about/products/budget-economic-data#3.

[79] Szcepanski, Kallie. “What was the Great Game?” ThoughtCo, July 31, 2019, https://www.thoughtco.com/what-was-the-great-game-195341

[80] US Congress. National Defense Authorization Act for Fiscal Year 2020 (P.L. 116-92 –Title IX Subtitle D Sections 951 – 961), December 20, 2019, https://www.congress.gov/bill/116th-congress/senate-bill/1790/text

[81] U.S. Space Force. “About U.S. Space Force,” 2019, Retrieved from https://www.spaceforce.mil/About-Us/About-Space-Force.

For context, the US was the third nation to organize a space force, following Russia and China:

- On December 14, 2014, Russian Defense Minister Sergei Shoigu announced that the Air Forces (Voyenno-Vozdushnye Sily—VVS) and the Aerospace Defense Forces (Voyska Vozdushno-Kosmicheskoy Oborony—VKO) had been merged into an entirely new structure as their “space force.” McDermott, Roger. “Russia’s Defense Leadership Reflects on 2014.” The Jamestown Foundation, Eurasia Daily Monitor Volume: 12 Issue: 7. January 13, 2015, https://jamestown.org/program/russias-defense-leadership-reflects-on-2014/#.VLeBxCvF-3w.
- On December 31, 2015, China’s People’s Liberation Army announced the creation of their “Strategic Support Force.” Pollpeter, Kevin L.; Chase, Michael L.; and Heginbotham, Eric. “The Creation of the PLA Strategic Support Force and Its Implications for Chinese Military Space Operations.” RAND Corporation, 2017. https://www.rand.org/pubs/research_reports/RR2058.html.

[82] 2017 National Security Strategy, page 31, as cited in footnote 26.

[83] To execute this strategy, the United States needs to move beyond playing strategic reactive defense, and start planning an agile strategic offensive game in space. The United States should not settle to only dominate an adversary at a specific time and place of their choosing; the United States must regard space as critical infrastructure through which superiority everywhere at all times assures “freedom of action” alternatives as vital to the national interest for current and future generations.

See Sadat, Mir. " Great Power Competition in Space," Potomac Institute, June 2019, https://www.terrorismelectronicjournal.org/app/download/9285322982/Dr+Mir+Sadat+Edited+Transcript+5.14.19.pdf?t=1560178085

4. THE GREAT GAME OF ECONOMICS AFOOT IN SPACE

Corporate Leadership Foresaw Today's Superpowers' Economic Rivalry

"There are two basic forms of human organization: the free societies, such as the United States; and the regimented societies, such as the Soviet Union. In free societies, the government is the servant of the people. In regimented societies, the people are the servants of the government.

No society is completely free or completely regimented, but the distinction is real and it is profoundly important to the quality of human life. The two systems are now engaged in a protracted struggle for the future of the world. They are competing in every field of human endeavor, including the field of economic development.

"A distinguishing feature of the free societies, as opposed to communist and other socialist systems, is the use of competitive private enterprise as the primary means of economic development. The citizens of the United States have both philosophical and practical reasons for preferring business enterprise to government enterprise. Philosophically, the competitive private-enterprise approach is more appropriate to a free society than government-owned or government-controlled industry, which is one of the characteristic features of a regimented society. And practically speaking, the system of competitive private enterprise has enabled this country to produce a level of living that is unmatched anywhere, anytime."[84]

Ralph J. Cordiner, Chairman of General Electric Company, 1961

Leveling the Playing Field for US Companies

The United States faces global competitors operating under economic policies and practices that they alone determine. In the extreme, their policies and unfair practices disadvantage US national security and global competitiveness. They also present disadvantages regarding supply chains available to public and private sector activities in space, the price of building and using space assets, the financing and insuring of space assets, and the talent, intellectual capital and technologies to design, manufacture, maintain, network, and improve them.[85]

This Report distinguishes three types of economic policies and practices: Open/Market-Driven, Closed/State-Controlled and Hybrid.

1. **Open/Market-Driven Economics** require full transparency, consistent regulatory frameworks and a history of both from which market participants—suppliers, their customers, banks, investors, and insurers—can make decisions with predictable outcomes yielding reasonable profit in light of attendant risks. An example is the US stock market, with the caveat that government demand, tax policy, and regulation indirectly support companies listed on the stock exchanges to a greater or lesser degree.
2. **Closed/State-Controlled Economics** rely on the national or regional government to assemble disparate information about the market and disseminate that information to specific market participants and government officials. The government directs investments to state-owned, controlled, favored enterprises, or private sector suppliers producing, financing, or trading the goods

and services. The government issues procurements and adopts fluid regulatory frameworks to establish and ensure the industry's short- and long-term demand curve and success. An example is the US agriculture market where the US Department of Agriculture plays a pivotal role in creating and stabilizing demand while reducing crop failure and other risks to farmers.

3. **Hybrid Economics** blend both systems, showcasing their Open/Market-Driven characteristics while downplaying the government's role as the prime customer, guarantor, investor, and insurer to stimulate demand and absorb risk. The hybrid approach leverages government financial support to attract private capital and risk-taking. An example is the defense industry where DoD is the primary defense industry customer for dual-use technologies, products and services, and the sole customer for military, intelligence, and other purposes.

Ever since the Cold War, America's economic policymaking framework for space dominance has lagged in long-range perspective, planning, funding, coordination, sustainability, and implementation. This gap in US "space economic engineering" stands in contrast to the nation's game-changing engineering, manufacturing, and technical achievements that enable the space economy.[86]

Over the last six decades, China has evolved as an economic power that views the United States as a rival. Through a series of multi-generational five-year plans, China has woven together investments, policies, state-owned enterprises, talent, and many other components of competitive advantage to pursue its long-term economic and national security goals for, to, and in space.[87]

How will the United States strategically compete steady-state in the next four to six decades as China continues to leap-frog?

The US government must fully employ all available national instruments and tools of power. US long-range economic policymaking must ensure all stakeholders transparency, clarity, and coordinated cooperation resulting in optimal market function and robust private sector capital investment.

US New Space entrepreneurs, investors, and the talented teams they recruit and train face non-technical uncertainties, including:

- Anticipating - but not overshooting - the demand curves for their interdependent assets, products, and services in space, especially when such demand curves are held captive to federal contractors who are beholden to entrenched industry and government interests;
- Navigating the ever-changing, delaying, and costly maze of layers of unmapped federal and state government regulatory incentives, licenses, and taxes that lack coordination and alignment; and
- Investing capital in research, manufacturing, and supply chains to meet and anticipate the space needs of government agencies whose needs remain siloed even among programs in related orbits or space technologies, such as the need for cyber-security of satellite control or tracking and space debris protection of

orbital assets.

ENDNOTES

[84] In his 1960 address on space, Ralph Cordiner emphasized the need to pivot from purely government funded and determined economic space policy to one that responsibly unleashed the full potential of private sector ingenuity, risk-taking and entrepreneurial talents. See Cordiner, Ralph. “Competitive Private Enterprise in Space,” Symposium on the Peacetime Uses of Space, University of California - Los Angeles, May 4, 1960, https://rjacobson.files.wordpress.com/2011/02/cordiner-article-1961.pdf

[85] Such as economics, technologies, territories, and other forms of capital that allow participants to own, borrow, use, and grow within economic systems.

[86] Notable exceptions include NASA’s and DoD’s use of Other Transactions Authority (OTA) to collaborate through nontraditional commercial orbital transportation and other business models.

See NASA, Commercial Orbital Transportation Services: A New Era in Spaceflight, February 2014, https://www.nasa.gov/sites/default/files/files/SP-2014-617.pdf; Office of the Under Secretary of Defense for Acquisition and Sustainment, Other Transactions Guide (Version 1.0), November 2018, https://www.dau.edu/guidebooks/Shared%20Documents/Other%20Transactions%20(OT)%20Guide.pdf; Schwartz, Moshe and Peters, Heidi. “Department of Defense Use of Other Transaction Authority: Background, Analysis and Issues for Congress,” Congressional Research Service, February 22, 2019, https://fas.org/sgp/crs/natsec/R45521.pdf

[87] For a comprehensive overview of China’s whole of government / whole of society efforts, see Stokes, Mark et al. “China’s Space and Counterspace Capabilities and Activities,” Prepared for the U.S.-China Economic and Security Review Commission March 30, 2020, https://www.uscc.gov/sites/default/files/2020-05/China_Space_and_Counterspace_Activities.pdf

5. WINNING THE GREAT GAME OF ECONOMICS IN SPACE

What History Teaches about Winning the Space Economy

"After decades of centralized control of economic activity in space, NASA and US policymakers have begun to cede the direction of human activities in space to commercial companies.

Many New Space companies have business models that make sense only when other, complementary models are already in place. Consider some technologies widely believed to be essential for the commercialization of space: low-cost, frequent launch capabilities; in-space manufacturing; scalable habitats; in-space resource extraction and energy collection; and reliable radiation shielding and debris mitigation. Individually, each of these technologies has only a limited payoff. Low-cost launches are still expensive if there is nothing to do and nowhere to go in space. Building habitats for manufacturing or tourism is of no use if they cannot be secured from the dangers of space. And so on. If these technologies were realized together, however, they would form a self-sustaining system with potentially enormous profit potential. In the economics of human space activities, the whole may be much greater than the sum of the parts.

One can imagine a self-reinforcing virtuous cycle of development that would support the space economy.

But one can also reasonably doubt that such an ideal path will be realized easily or without some nudges along the way. Limits on or asymmetries of information, the high level of risk inherent in space and the challenges of capturing surplus from such complementarities will make it difficult to move forward on the most efficient path—or even to move forward at all."[88]

Matthew Weinzierl, Harvard Business School Professor, 2018

Global competitors and great power adversaries tightly couple and integrate their government industrialization policies, sovereign wealth investment policies, and government-owned industrial base.[89] Doing so ensures short- and longer-term funding through the research, development, prototyping, manufacturing, marketing of space assets, and products and services - many for military and intelligence use.

Instead of relying on tight integration, the US economic system relies on distributed, trustworthy markets and the investment possibilities they offer. The US economic system has developed robust financial market structures, consistent rules, transparency, and types of financial instruments (i.e., stocks, bonds and commodities contracts) to enable investors to supply capital in amounts and at rates of return that make sense. The United States should rely on and adapt decades of precedents by which government-guaranteed loans, government procurement commitments, and government market supports were used to catalyze and sustain new markets before commercial space.

Commercial space is a critical infrastructure for daily life, business and government functions, and national security. And now, the USSF is part of the military industrial base, which is a critical infrastructure to US national security.

America's commercial space industry is comparatively nascent. It competes for investment capital and low-interest loans against terrestrial industries for whom the market demand and other dynamics are relatively predictable and in certain industries, the federal government guarantees demand. Given the national security interest in establishing and growing healthy domestic space companies, the United States needs to foster the development of US financial market infrastructure that understands the space economy and ensures funding for space companies and their customers and suppliers throughout their lifecycles as new and growing firms.

However, the financial engineering for US space has so far been omitted from and is still unaddressed in public national economics and policymaking, critical infrastructure assurance and ***financial innovation frameworks.***[90]

Federal financial incentives often are used to grow critical infrastructure industries.[91] The US energy industry would not exist today without federal financial incentives.[92] In 2020 dollars, by one set of estimates, the nation's energy industry relied on federal financial incentives of $915 billion over a 50-year period (1953 - 2003) and $1.45 trillion over a 66-year period (1950 - 2016). The incentives were used to develop, shift, and deploy sources that supply the benefits enjoyed as continuous reliable electricity to power the digital economy, cities, the Internet and soon airplanes, automobiles, and trucks. The energy industry matured into a diverse array of intermodal components and networked supply chains, distribution channels, and storage capacities. Incentives, as summarized in Appendix A, included favorable federal and state tax deductions and tax rates, regulatory incentives, research and development grants, cooperative arrangements, direct federal procurement, and market activity.

Raw materials, processed goods, services, financial futures, and risk transfer hedges essential for the energy industry are traded as commodities on global commodity and specialty exchanges. Investors, lenders, and speculators have a wide variety of financial instruments through which to fund the energy industry and the commodities upon which it relies, while simultaneously trading options that diversify their risks.

The energy sector is one of 18 Critical Infrastructure Sectors that rely on access to communications, imagery, and other services of satellites in space for resource exploration and mining, load management, facilities security, and other purposes.[93]

National security and the industrial base are made vulnerable because ***Commercial Space has yet to be explicitly declared and financed as a critical infrastructure sector.***[94]

ENDNOTES

[88] Weinzierl, Matthew. "Space, the Final Economic Frontier," Journal of Economic Perspectives, Vol. 32 No. 2, Spring 2018, https://pubs.aeaweb.org/doi/pdf/10.1257/jep.32.2.173. [Excerpted asynchronously from the original]

[89] "The PRC State Council's 2017 Opinions on Promoting the Deep Development of Military-Civil Fusion in the National Defense Science and Technology Industry states a need to 'accelerate the overall

planning of space infrastructure according to the needs of the military and civilian sectors' as well as increase the number of MCF projects in the realms of launch vehicles, deep space exploration, nuclear-powered space equipment, remote sensing satellites and others." See Stokes, Mark et al. "China's Space and Counterspace Capabilities and Activities," Prepared for the U.S.-China Economic and Security Review Commission, March 30, 2020, page 59, https://www.uscc.gov/sites/default/files/2020-05/China_Space_and_Counterspace_Activities.pdf

[90] Space, in particular commercial space, is notably missing from national economic policymaking. See United States. Compilation of Presidential Documents. See United States. Economic Report of the President together with the Annual Report of the Council of Economic Advisers. Washington D.C: Office of the Federal Register, National Archives and Records Administration, February 2020, https://www.govinfo.gov/content/pkg/ERP-2020/pdf/ERP-2020.pdf

[91] Infrastructure is built up over thousands of public and private decisions, years and interdependent plans. Government infrastructure policy allows emergence of new sustainable investments and business models, such as the opening of the Internet, the Transcontinental Railroad, the Interstate Highway System, modern air and marine ports, hospitals and universities.

[92] Bezdek, Roger and Wendling, Robert. "A half century of US federal government energy incentives: value, distribution and policy implications," International Journal of Global Energy Issues, Volume 27 Number 1, 2007), Table 1, https://www.semanticscholar.org/paper/A-half-century-of-US-federal-government-energy-and-Bezdek-Wendling/d20c3fe371043777e5689c0687b08136d04d6992; Bezdek, Roger and Wendling, Robert. "Two Thirds of a Century and $1 Trillion+ U.S. Energy Incentives Analysis of Federal Expenditures for Energy Development, 1950-2016," Nuclear Energy Institute, May 2017, https://www.nei.org/CorporateSite/media/filefolder/resources/reports-and-briefs/analysis-of-us-energy-incentives-1950-2016.pdf. (Tables in Appendix A reflect adjusting cited dollar estimates for inflation / purchasing power in 2020 dollars: $1 in 2003 = $1.42 in 2020 and $1 in 2015 = $1.09 in 2020, respectively. Inflation Tool, https://www.inflationtool.com/us-dollar/2003-to-present-value?amount=1. Sources supplying 2003 and 2016 US Energy from US Energy Information Administration, "Annual Energy Review: Primary energy production by source Table 1.2," https://www.eia.gov/totalenergy/data/annual/)

An earlier study of federal investments in nuclear energy estimated (adjusted to 2020 dollars) that through 1988, national investment of $112 billion yielded net benefits of $669 billion, without counting the health and safety of workers in fossil fuel mining and other energy industry operations displaced by availability of nuclear power. See Bezdek, Roger and Wendling, Robert. "Costs and Results of Federal Incentives for Commercial Nuclear Energy," Energy Systems and Policy, Vol 15, 1991.

[93] United States. DCPD-201300092 - Directive on Critical Infrastructure Security and Resilience. Washington D.C: Office of the Federal Register, National Archives and Records Administration. 12 February 2013, https://www.govinfo.gov/content/pkg/DCPD-201300092/html/DCPD-201300092.htm; US Department of Homeland Security Cybersecurity and Infrastructure Security Agency. 18 Critical Infrastructure Sectors, March 24, 2020, https://www.cisa.gov/critical-infrastructure-sectors; Shaun Waterman. Space Industry Seeks Designation as Critical Infrastructure. Air Force Magazine, October 14, 2019, https://www.airforcemag.com/space-industry-seeks-designation-as-critical-infrastructure/.

[94] While Presidential Executive Order (EO) 13905 requires federal agencies to consider how existing critical infrastructure depends on positioning, navigation, and timing (PNT) services from satellites, the EO does not declare the commercial space industry as providing critical infrastructure. See United States. 85 FR 9359- Executive Order 13905 – Strengthening National Resilience through Responsible Use of Positioning, Navigation and Timing Services. Washington D.C: Office of the Federal Register, National Archives and Records Administration. 18 February 2020. https://www.federalregister.gov/documents/2020/02/18/2020-03337/strengthening-national-resilience-through-responsible-use-of-positioning-navigation-and-timing. While space is considered a "critical and emerging technology," the space industry is not designated as a "critical infrastructure." See United

States. (October 2020). “National Strategy for Critical and Emerging Technology,” Washington, D.C.: Executive Office of the President of the U.S., https://www.whitehouse.gov/wp-content/uploads/2020/10/National-Strategy-for-CET.pdf.

6. BARRIERS TO PROFITABILITY AS US SPACE ENTREPRENEURS SEE THEM

Facing and Overcoming Obstacles in Organizations

"My favorite things in life don't cost any money. It's really clear that the most precious resource we all have is time."

"We don't get a chance to do that many things and every one should be really excellent. Because this is our life. Life is brief and then you die, you know? And we've all chosen to do this with our lives. So it better be damn good. It better be worth it."

"Your time is limited, don't waste it living someone else's life. Don't be trapped by dogma, which is living the result of other people's thinking. Don't let the noise of other opinions drown your own inner voice. And most important, have the courage to follow your heart and intuition, they somehow already know what you truly want to become."

"You can't connect the dots looking forward; you can only connect them looking backward. So you have to trust that the dots will somehow connect in your future. You have to trust in something — your gut, destiny, life, karma, whatever."

"It's really hard to design products by focus groups. A lot of times, people don't know what they want until you show it to them."

Steve Jobs, CEO/Co-Founder Apple Computer, 2015[95]

The United States is a country built by, for and full of, inventors and innovative entrepreneurs who transformed the 19th, 20th, and 21st centuries for billions of people around the world. Innovative entrepreneurs come from the great diversity and randomness of circumstances that are the hallmark of the American spirit. They are optimists, passionate dreamers who assemble best-of-class teams to convert dreams into reality. Entrepreneurs devote their lives, personal reputations, and fortunes to bring innovations into the world: "From health care to finance, education to navigating space, agriculture to climate research, and from Hollywood to the Pentagon, innovation has been America's lifeblood. Innovation is new or improved art, products, processes, services, business models, or technologies."[96] Entrepreneurs' enthusiasm, dedication, and sacrifice are magnetic and inspire a new generation of entrepreneurs.

Blue Ocean Strategies and Space Entrepreneurship[97]

A new generation of entrepreneurs are exponentially growing the space industry by augmenting existing technologies and pioneering new business models. These entrepreneurs are pushing the innovation possibilities frontiers, similar to *blue ocean discoverers* of the earlier Industrial and Digital Eras. Over time, their unique innovation or its business model becomes part of everyday life and practice, and many competitors emerge to reproduce the capability. The crowded, competitive market is often called *red oceans* because suppliers compete based on price or scale aggressively within pre-existing product and service categories.[98]

By contrast, in the *blue oceans*, companies collaborate to enhance profitability and design their products to fit how customers would use them alongside others' products (known as product/market fit). *Blue ocean entrepreneurs* develop new business models

that upend how traditional industry players perceive end-user experience and the functionalities required to enhance the end-users' safety, productivity, and bottom line budgets. Often the technologies that build efficiencies in *red oceans* become the foundational technologies for *blue oceans* by bringing its human talent, patent portfolios, investors, regulatory approval, and market knowledge. Alternatively, the *red oceans'* technologies that could be foundational for a *blue ocean* are bottled up in traditional ways of thinking about the business models in which they have historically been researched, developed, marketed, and narrowly used.

Red Ocean Strategy	Blue Ocean Strategy
Compete in **existing** market space.	Create **uncontested** market space.
Beat the competition.	Make the competition **irrelevant.**
Exploit **existing** demand.	Create and capture **new** demand.
Make the value-cost trade-off.	**Break** the value-cost trade-off.
Align the whole system of a firm's activities with its **strategic choice of differentiation or low cost.**	Align the whole system of a firm's activities in **pursuit of differentiation and low cost.**

Space entrepreneurs innovate products and services that exist in *terrestrial red oceans* in abundant supply, and to adapt them for the *blue oceans of the space economy*. In effect, technologies such as 3-D design and printing, robotics, telecommunications, and solar power greatly impact modern life. That life depends on the fish in the *red ocean* that provide the feedstock for the *blue oceans* of the Earth's orbits, cislunar, asteroid, and other space economy domains. The transfer of know-how from *red ocean* to *blue ocean* serves as precedent, and reduces the risk of any given technology or business model up there by pointing to the terrestrial elements it embodies or replicates. The companies born or playing in the *blue ocean* and the talent they attract readily swim within and between the *red* and *blue oceans* with a vitality and community trust.

During the last 20 years when the United States' focus was counterterrorism, American had the technological innovative advantage because it dominated both the *blue* and *red* oceans, and outpaced terrorist groups and their state-sponsors. Today, technological innovation is an ever-accelerating global competition among great powers and terrorist groups that transcends borders.[99]

National investments needed for great power competition have now surpassed US expenditures on counterterrorism, and are approaching Cold War-era levels: "The foundation of war is economics. If you have half the resources of the counterparty then you better be real innovative. If you're not innovative, you're going to lose."[100] Global competitors such as the Chinese government seek to control *blue* and *red* oceans by investing along all stages of research, supply chains, finance and inter-locking markets for their industries and quasi-private companies in order to dominate global markets, which, if carried out illegally or as unfair competition, disadvantages US companies, copies US innovative technologies, and discourages American innovators.[101]

The US government must track and mitigate threats to America's innovation base: "The technological innovations of the past 10 years have been exponentially greater than those that have been achieved over the previous 2,000 years combined. While even more innovation is expected over the next 10 to 15 years, America is projected to lose its innovation ecosystem and political leadership to China."[102] America's innovators need moonshot policies and reforms to responsibly unleash the US innovative base.

American innovators must be the first to disrupt US markets, rather than others who could render particular industries potentially obsolete or engage in unfair or anti-competitive trade practices. Steve Jobs provides a case in point: Apple constantly invested in new technologies and customer experience business model that disrupted Apple's own market and prior products iterations to make them cheaper, more user-friendly, and cutting edge, such as how iTunes replaced the iPod for music and the iPad is replacing the desktop computer. Apple's *blue ocean* strategies retained and grew its global market leadership, outpacing rivals who remained in established *red oceans*.

Obstacles Along the Road Faced by US Companies

US industrial policy centers the competitive landscape for US companies, their talented workforce, their supply chains, financing and taxation. US companies can choose to be headquartered in the US or to move their corporate nexus to countries with more friendly regulatory, tax and other industrial policies. However and wherever a US company chooses to conduct its research, manufacturing and distribution operations, foreign companies are making their choices, assisted by, or in direct accountability to, US allies' and adversaries' industrial policies. Indeed, the United States is competing with foreign nations to create and rapidly adapt regulation of emerging technologies,[103] which makes regulatory agility a key factor in commercial space sector growth. For example, comparing how United States and Chinese companies see their competitive landscapes as a function of national industrial policy yields questions along the lines of the following chart.

Challenge	US Company View	Chinese Company View
Complexity of Regulatory Compliance & Oversight	Too complex & unmapped	**You help us, we'll help you**[104]
Persistent Availability of Financing	Depends on the size/age of company & whether VCs are investing, banks are lending & insurers are insuring. In general software is more attractive investment than hardware in capital markets.	**One can always raise funding in a centrally managed economy. We are immune to adverse forces in the free market economy**[105]
Certainty of Government's Future Demand for Space Asset or Service	Annual appropriations & constant reorganizations of government functions undermine predictability of government commitments	CCP Grand Strategy establishes goal of surpassing US as the dominant space power by 2045[106]
Access to Robust, Updated Business Intelligence as to Competitive Landscape	Limited, trustworthy data is developed or shared commercially. Intellectual property rights are paramount.	Over the past several thousand years, vast numbers of outstanding Chinese scientists, inventors, writers and artists have given the glorious fruits of their mental labor to the development of humanity's common civilization.[107]
Protections against Intellectual Property (IP) of Failed Companies being Acquired	Very little	[Unknown]
Space Economy & Industrial Policy is seen & supported Long Term as Elements of National Security	No national commitment to develop, fund & use space infrastructure	Space is a component of China's Belt and Road Initiative[108]

Reviewing the competitive landscapes enabled or constrained by US industrial policy as compared to those in other nations raises additional real-life questions for the commercial space company's leadership, including:

1. How will government realign its multiple layers of inconsistent incentive and regulatory policies to let the future entrepreneurs succeed?
2. What advantages and disadvantages do US commercial space entrepreneurs face, as compared to their global competitors in ally and adversary nations?
3. As compared to other nations, is the US government effectively and holistically using its ongoing role in developing commercial space sector through procurements, incentives, guaranteed loans and market participation in such private investment activities?
4. Is government process, procedure and regulation helping or hurting US commercial space entrepreneurs, and how should the enormity of regulatory burden be monitored to comparatively help more than hurt? For instance, is it easier for commercial space companies to move offshore and get licensed in Asia or Europe?
5. Who, trained or educated in the United States, will become, and have the fair opportunities to become, the "Steve Jobs" of the Commercial Space Age?

ENDNOTES

[95] Slater-Robins, Max. *15 Inspirational Quotes from Steve Jobs* (Business Insider – September 29, 2015), https://www.businessinsider.com/steve-jobs-quotes-life-advice-2015-9.

[96] Mir Sadat, *Why innovation is so important to America's global leadership* (The Hill – November 22, 2020), https://thehill.com/opinion/technology/526535-why-innovation-is-so-important-to-americas-global-leadership.

[97] This discussion of red oceans and blue oceans draws upon the work of Kim, W. Chan and Mauborgne, Renée. (October 2004) "Blue Ocean Strategy," https://hbr.org/2004/10/blue-ocean-strategy, and Kim, W. Chan and Mauborgne, Renée. (February 2019) "SpaceX Creates Its Own Market Space – in Outer Space," https://www.blueoceanstrategy.com/blog/spacex-creates-space-outer-space/. Red oceans/blue oceans graphic from Blue Ocean Strategy & Shift Tools, https://www.blueoceanstrategy.com/tools/red-ocean-vs-blue-ocean-strategy/.

[98] In red oceans, a company wins that offers the lowest price or influences major segments of demand, patented technologies, or supply chains.

[99] Mir Sadat, *Why innovation is so important to America's global leadership* (The Hill – November 22, 2020), https://thehill.com/opinion/technology/526535-why-innovation-is-so-important-to-americas-global-leadership.

[100] Air Force Association. Elon Musk and Lt Gen JT Thompson. "YouTube Video." February 28, 2020. https://www.youtube.com/watch?v=E307nHamdY8

[101] Ibid, footnote 99.

[102] Ibid, footnote 99.

[103] Eggers, William D.; Kishnani, Pankaj; and Turley, Mike. "The future of regulation: Principles for regulating emerging technologies." Deloitte Insights. June 19, 2018. https://www2.deloitte.com/us/en/insights/industry/public-sector/future-of-regulation/regulating-emerging-technology.html.

[104] Buckley, Chris and Bradsher, Keith. “China’s Communists to Private Business: You Heed Us, We’ll Help You - Party leaders have pledged to increase their influence over entrepreneurs even as they promise greater aid, reflecting Xi Jinping’s greatest — and sometimes conflicting — challenges.” N. Y. Times. September 17, 2020. https://www.nytimes.com/2020/09/17/business/china-communist-private-business.html.

[105] Murdoch, Scott and Zhu, Julie. “Chinese companies take record 50% of global equity raising in first half of 2020.” Reuters - June 28, 2020. https://www.reuters.com/article/asia-ipo/chinese-companies-take-record-50-of-global-equity-raising-in-first-half-of-2020-idUSL4N2E02K1.

[106] Goswami, Namrata. “China in Space: Ambitions and Possible Conflicts.” Strategic Studies Quarterly Vol. 12, No. 1 (SPRING 2018), pp. 74-97, https://www.jstor.org/stable/10.2307/26333878.

[107] Information Office State Council Of the People's Republic of China. “Intellectual Property Protection in China.” June 1994. http://www.china-un.ch/eng/bjzl/t176937.htm.

[108] Huang, Echo. “China is building its new Silk Road in space, too.” Quartz – June 18, 2020, https://qz.com/1276934/chinas-belt-and-road-initiative-bri-extends-to-space-too/

7. CAPITAL IS KEY IN GLOBAL COMPETITION

New Space Investment Challenges amidst the Digital Age

"Ever since the Industrial Revolution, investments in science and technology have proved to be reliable engines of economic growth. If homegrown interest in those fields is not regenerated soon, the comfortable lifestyle to which Americans have become accustomed will draw to a rapid close." [109]

Neil deGrasse Tyson, astrophysicist & Director Hayden Planetarium, 2012

Global Competition for Investment Capital

Every US company competes against other companies (and governments) - domestic and foreign - to attract global capital based on the financial markets' perceptions of their capacities to (1) repay investors' principal and (2) earn reasonable risk-adjusted returns.[110] Financial instruments, their yield, how many days/months/years they will transfer capital before requiring repayment, and the risk of repayment of principal and interest are tailored to match where the company receiving the capital is in its lifecycle of creating a viable business model, developing its talented workforce, trust in supply chains, carving its niche in the market, and generating proven revenues. The financial instruments are traded as and through equity (i.e., stocks), debt (i.e., bonds and credit instruments), and commodities (i.e., options, derivatives, swaps and indexes) by family offices, pension funds, retirement accounts, mutual funds, limited partnerships (e.g., venture capital and private equity funds), and other structures to invest in private equity, private debt, real estate, natural resources, infrastructure, and other fund and asset classes.

Early Stage Venture Capital

Venture capital (VC) as a financial asset class receives a lot of attention in the New Space economy. The United States and many other developed nations have optimized the process of venture capital funding of space and non-space startup companies. (See Appendix B).

VC investments ($385 billion) in 2019 constituted 0.11% of global household wealth ($360.6 trillion) deployed through global financial markets, as suggested in Appendix C. Private equity ($5.23 trillion) - of which venture capital is classified as a part - comprises 1.45% of total household wealth ($360.6 trillion).[111]

The VC investment thesis supports many startup companies by acknowledging that only a small fraction will ultimately succeed in disrupting established industries or launching new ones, as depicted in Appendix D.[112] VC investors assume a significant failure rate for the startup companies that their funding launches, as depicted in Appendix D. A high proportion of venture capital returns come from a handful of their investments, with the other startup companies and their human and intellectual capital either incorporated piecemeal into successive startups, or liquidated and sold.

Although American venture capitalists still provide the majority of global VC, foreign VC investors are becoming increasingly critical. As Appendix E suggests, foreign investors, albeit as limited partners in successive rounds of VC funding, indirectly control the

assets, strategic directions, future fundraising terms, and liquidation of VC-backed startups in key and emerging industry segments.[113] Foreign venture capital both enlarges the pool of early risk-takers for New Space companies and adds complexity in managing investor relations to comply with US national security requirements and concerns regarding sensitive technology and manufacturing assets, intellectual property, and innovation.

Growth Capital

As rewards for their risk-taking as early investors, venture capitalists curate their portfolios based on available AI/ML, consumer, healthcare, space, or other technology industry verticals and aim for lucrative investment capital exits via merger or initial public offering (IPO) – known as "going public" - on a major stock market such as the New York Stock Exchange (NYSE) or the NASDAQ.

As companies mature from startups with early-stage proofs of concept and product/market fit, they outgrow the high cost and short timeframe of venture capital. They seek other types of financial capital at lower rates of return and for longer maturities before repayment or refinancing is required.

Since space is a multi-year business, the space economy must develop financial equity (stocks), debt (bonds), and commodities instruments that validate, match, and de-risk the lifecycles of assets to be designed, manufactured, operated, and serviced over time periods extending beyond the short-term (2 - 5 years) appropriate for VC funding.

Capital Looks to the US Government as an Early Stage Customer

The US government serves as an initial validating customer for New Space startups and as a national steward of their potentially valuable assets, technologies, and team members facing gaps in successive VC funding rounds. The reason venture capitalists fund certain New Space startups may be randomly dispersed for portfolio balancing purposes. VC funding of New Space may be myopic, and incapable of taking into account the actual value or viability of a company's technology, or the potential size of the product's total addressable market (TAM), if the New Space economy were viewed holistically as interdependent.

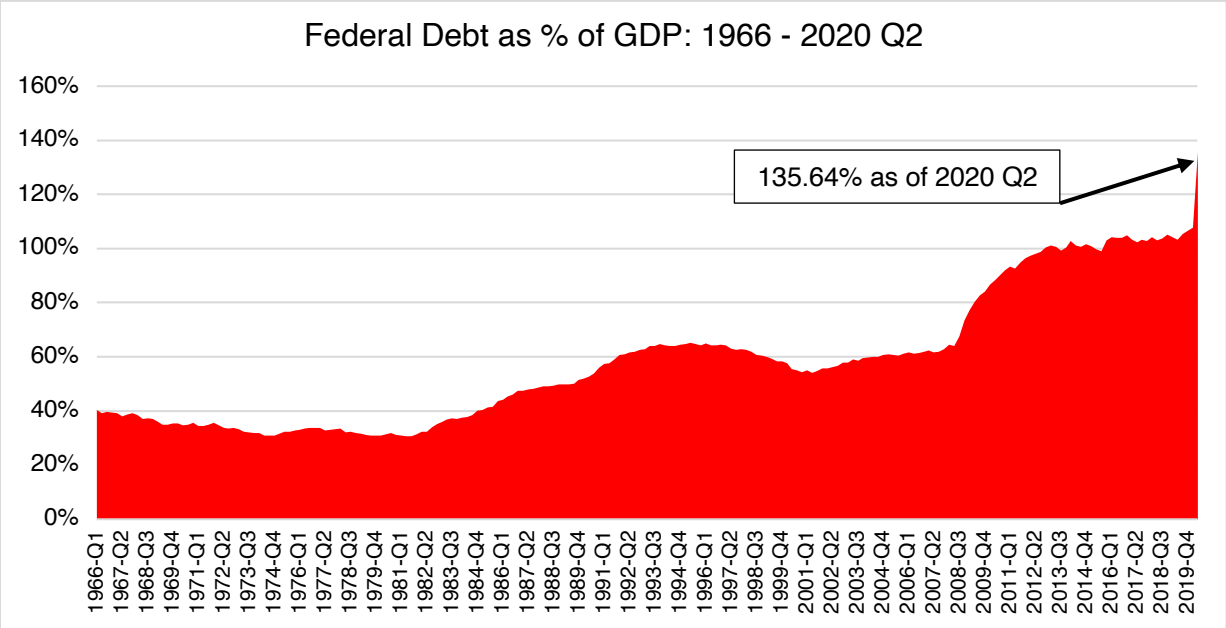
The United States has a vested interest in objectively tracking and de-risking the economics of space venture funding, its inherent short-term bias, and the risks to entrepreneurs overly dependent on VC funding or the structural advantages that foreign space competitors unduly enjoy in buying US VC-backed companies' technologies at liquidation sale prices.

Venture Capital is Cyclical and Dries Up During Recessions without Government Demand

During the last five years, $11 billion of private capital has been invested in commercial space technology companies[114] whose most promising end-users were US government agencies or missions. The current lack of return on early investments in space, coupled

with a lack of growing demand, could deter further private investment. Without actions such as those called for in this Report's recommendations, the expected post-COVID-19 global recession may delay or disrupt further private investments in the space sector, as VCs and their institutional limited partners (e.g., universities, pension funds, private wealth and sovereign wealth clients) reallocate their investment portfolios to fund pandemic-response biotechnology, logistics, remote work, corporate debt and other near-term terrestrial opportunities.[115] Thus far in 2020, the global pace of commercial space investments have weathered the COVID-19 recession,[116] and remote work may fuel continued investor interest in space assets that provide terrestrial value such as GPS.[117]

Fiscal constraints exacerbated by COVID-19 spending will dry up many sources of future government demand. The federal government will face severe near- to medium-term deficits that may constrain government borrowing. At the end of fiscal year 2019, the ratio of federal debt ($22.8 trillion) to GDP ($21 trillion) was 79%, the highest in US history except for the six years during and immediately following WWII.[118] As of April 2020 (before ongoing federal stimulus borrowing to mitigate COVID-19), federal debt stood at 136% of GDP.[119] Around $9.9 trillion (43% of total federal debt) of the outstanding amount of publicly held Treasury securities are scheduled to mature in the next four years. Federal debt is currently on track to exceed GDP growth. This imbalance is unsustainable in the long-term without decreased spending or increased revenue.[120]



Public financing for R&D was at historic lows even prior to the COVID-19 pandemic. With the additional stimulus measures taken in response to the COVID-19 pandemic, the federal government will face greater pressure to make cuts to R&D spending in the coming years.

Consolidations in the aerospace industry are highly correlated with government fiscal and programmatic decisions and national recessions. The consolidations trigger disparate economic impacts, workforce displacements, and cause the government to depend on an oligopoly of defense prime contractors for innovation.[121]

Merger and acquisition (M&A) activity can be a healthy sign that the disruptive companies and their technologies are becoming dominant trends, or it can signal that legacy companies and their business models are taking defensive moves to stymie being disrupted, or the M&A deals may stem from a combination of both.[122]

Decreases in new venture funding may force - perhaps prematurely - capital-constrained entrepreneurial space firms to partner, merge, or combine with larger companies or be acquired by private equity firms to keep their teams together and continue to aggressively move forward in executing their business plans. There are several well-funded entities attempting roll-ups of companies in the New Space sector to create stronger, more diverse, and synergistic businesses. Various mechanisms for tapping public equity markets, such as Virgin Galactic used in its SPAC: Special Purpose Acquisition Company,[123] offer access to cheaper equity market capital for a portfolio of space companies without each company incurring the separate regulatory costs and reporting burdens of IPOs: Initial Public Offerings.[124] They can then affordably finance these businesses and present lower-risk alternatives to customers. With support from the financial community, responsible financial engineering innovations could create a new tier of moderate-sized companies that are still highly innovative, but more sustainable than a large pool of small, underfunded competitors.[125]

The magnitude and success of the space industry's post-COVID-19 recovery are uncertain and unpredictable. Maintenance and growth of the US space industrial base through private capital require adequate returns on investment in startup, launch, services, manufacturing, and logistics companies.

COVID-19 has produced a global economic recession that provides a dangerous opportunity for near-peer competitor nations to challenge or surpass the United States in space. They can do so by (1) strategically acquiring companies and their intellectual property (IP) and/or (2) maintaining investments while the US private capital is unavailable, and the US government is focusing on competing priorities. The present levels of venture capital driving US space innovation will likely taper off, requiring that the US government reassert itself as primary driver and long-term horizon investor for space development

Patient Capital – The Result of Financial Market Transparency, Liquidity, and Alchemy

"Patient capital" is invested for the long-term, five years or more, directly in a specific asset like real estate, or increasingly in private equity or other funds with expertise in such style of investing.[126]

Recent trends in asset management favor looking past daily share price movements in publicly-traded stocks in order to find companies that have the management, intellectual

curiosity, and knowledge of niche market opportunities to cultivate unique expertise. The year 2020 saw the launch of a specialized stock exchange - the Long Term Stock Exchange (LTSE) - where such companies' financial performance could be compared to like-kind peers.[127] To address environmental and social inequalities, patient capital in the form of impact investing is growing as an allocation of institutional portfolios, whereby quantifiable impacts created by the investee are rewarded through reduced revenue-sharing or other charges.[128]

The space economy must grow a robust mix of equity and collateralized debt investment structures to conform to the diversified portfolio approach of patient capital investments.

ENDNOTES

[109] Tyson, Neil deGrasse. "The Case for Space: Why We Should Keep Reaching for the Stars," Foreign Affairs, Vol. 91, No. 2, March/April 2012.

[110] Gadzinski, Gregory; Schuller, Markus; and Vacchino, Andrea. "The Global Capital Stock. A Proxy for the Unobservable Global Market Portfolio, "October 3, 2016, http://dx.doi.org/10.2139/ssrn.2808438; Claudio Raddatz, Sergio Schmukler and Williams, Tomaás. International Asset Allocations and Capital Flows: The Benchmark Effect, World Bank, Policy Research Working Paper No. 6866, May 2014, https://openknowledge.worldbank.org/bitstream/handle/10986/18337/WPS6866.pdf?sequence=1.

[111] Credit Suisse. Global wealth 2019: The year in review (October 2019, https://www.credit-suisse.com/about-us/en/reports-research/global-wealth-report.html; McKinsey & Company. A new decade for private markets: McKinsey Global Private Markets Review 2020, February 2020, https://www.mckinsey.com/~/media/mckinsey/industries/private%20equity%20and%20principal%20investors/our%20insights/mckinseys%20private%20markets%20annual%20review/mckinsey-global-private-markets-review-2020-v4.ashx.

[112] CB Insights. "Venture Capital Funnel Shows Odds Of Becoming A Unicorn Are About 1%," September 6, 2018, https://www.cbinsights.com/research/venture-capital-funnel-2/

[113] National Venture Capital Association. "2020 Yearbook, March 2020," page 18, https://nvca.org/wp-content/uploads/2020/04/NVCA-2020-Yearbook.pdf.

[114] Quilty, Chris and Cadman, Justin. Recession Impact on Venture Space Ecosystem, April 20, 2020, https://www.quiltyanalytics.com/wp-content/uploads/2020-0420-Venture-Space-Investing-Report-Page1.pdf

[115] Alternative investments are discussed at footnote 75.

[116] Space Capital. "Space Investment Quarterly: 2020 Q3." October 15, 2020, https://www.spacecapital.com/publications/space-investment-quarterly-q3-2020.

[117] Space Capital and Silicon Valley Bank. "The GPS Playbook: How a space-based technology generated the largest venture outcomes in history." March 2020, https://spacecapital.docsend.com/view/r6655fe.

[118] US Government Accountability Office. "America's Fiscal Future." https://www.gao.gov/americas_fiscal_future.

[119] Federal Reserve Bank of St. Louis. "Federal Debt: Total Public Debt as Percent of Gross Domestic Product (GFDEGDQ188S)." September 30, 2020, https://fred.stlouisfed.org/series/GFDEGDQ188S.

[120] Ibid.

[121] Boatner, Amy. "Consolidation of the Aerospace and Defense Industries: The Effect of the Big Three Mergers in the United States Defense Industry," Journal of Air Law and Commerce Volume 64 Issue 3

Article 12 (1999), https://scholar.smu.edu/jalc/vol64/iss3/12/.

[122] DeSanto, Kipp & Co. Investment Bankers. “Aerospace / Defense & Government Services 2020 M&A Survey as of January 31, 2020.” https://kippsdesanto.com/wp-content/uploads/2020/04/KippsDeSanto-MA-Aerospace-Defense-Survey.pdf

[123] Renaissance Capital. “The Space SPAC: Everything You Need to Know about Virgin Galactic.” October 28, 2019, https://www.renaissancecapital.com/IPO-Center/News/65718/The-Space-SPAC-Everything-You-Need-to-Know-about-Virgin-Galactic.

[124] Contrast, a proponent of SPACs, Palihapitiya, Chamath. Annual Letter to Social Capital Shareholders.” March 9, 2020, https://www.socialcapital.com/annual-letters/2019, with Gara, Antoine; Haverstock, Eliza; and Klebnikov, Sergei. “How SPACs Became Wall Street’s money Tree: How hedge fund traders known as the SPAC Mafia are driving an $80 billion investment boom with a no-lose trade.” (Forbes – November 19, 2020), https://www.forbes.com/sites/antoinegara/2020/11/19/the-looming-spac-meltdown/

[125] In the aerospace industry, moderate sized companies rarely stayed independent for long and got absorbed through acquisition into a few aerospace primes. Bugos, Glenn E. “The History of the Aerospace Industry.” Economic History Association, https://eh.net/encyclopedia/the-history-of-the-aerospace-industry/

[126] Ivashina, Victoria and Lerner, Josh. “Patient Capital: The Challenges and Promises of Long-Term Investing.” https://press.princeton.edu/books/hardcover/9780691186733/patient-capital.

[127] Long-Term Stock Exchange, https://longtermstockexchange.com/listings; Nguyen, Lananh. (September 9, 2020). “Silicon Valley Stock Exchange Debuts in Search for First IPO.,” https://www.bloomberg.com/news/articles/2020-09-09/long-term-stock-exchange-debuts-as-it-searches-for-first-listing.

[128] Trelstad, Brian. (June 29, 2010). “Patient Capital in an Impatient World,” https://www.kauffmanfellows.org/journal_posts/patient-capital-in-an-impatient-world; Brown, Duncan and Fogg, Duncan. (2020) “Beyond Demand: The social sector’s need for patient, risk-bearing capital,” https://shiftdesign.org/content/uploads/2020/05/Beyond-Demand-Report_Shift_EsmeeFairbairn.pdf.

8. US FEDERAL FINANCE GREW KEY US INDUSTRIES

Role of US Government Financing in Expanding New Economic Frontiers

"[T]he US government promoted key industries by another means, namely, public funding of R&D. Between the 1950s and the mid-1990s, US federal government funding accounted for 50-70% of the country's total R&D funding, which is far above the figure of around 20%, found in such 'government-led' countries as Japan and Korea. Without federal government funding for R&D, the US would not have been able to maintain its technological lead over the rest of the world in key industries like computers, semiconductors, life sciences, the internet and aerospace."[129]

Ha-Joon Chang, political economist at University of Cambridge, 2008

Assuring the Full Range and Timeframe of Capital that US Space Companies Need

The commercial ecosystem requires a range of short-term and long-term financial tools to match the lifecycles of its different parts and the evolving roles and capital needs of its companies, their supply chains, and their customers. The financial history of terrestrial economies demonstrates that national prosperity, security, and independence hinge on ensuring that domestic capital readily funds the era's innovative technologies and the companies producing them. On behalf of many industries and their customers, the federal government often directly or indirectly through government-sponsored enterprises (GSEs) serves as a "credit enhancer" via financial guarantees of payment or performance.[130] For example, starting and growing a small business became more financeable with Small Business Administration (SBA) guaranteeing loans at lower interest rates and special incentives for banks to invest in small businesses via small business investment companies (SBICs), while bank regulators kept score of banks' community and small business lending activity.[131]

Committing to Financing Mechanisms for the US Space Industry

Financing space requires the nation to invest in durable financial market mechanisms. When finance mechanisms perform accountably for the real economy,[132] they produce companies owned and controlled by US citizens that generate competitive paying jobs in the United States. They also control critical space technologies and ensure domestic supply chains for their long-term success.

The Export–Import Bank example provides lessons in the strategic consequences of thinking short- versus long-term in providing national financial mechanisms to the space industry. To expand and price US space industry exports attractively for foreign buyers, the Export–Import Bank credit enhances US aerospace and space industry loans to reduce their interest rates, which in turn reduces the debt service costs to all parties.[133] However, for nearly four years the Bank was de-authorized and political uncertainties surrounded it re-authorization.[134] During those four years, the US companies and their subcontractors were put in an uncompetitive position. Foreign buyers of US exports had to buy equivalent space services from US allies' or from China and Russia.

US Government Economic Policymaking Precedents for Space Finance

Many terrestrial financial markets and the capital they supply to US industries carry explicit or implicit US government guarantees or other forms of participation through GSEs or markets that receive government support for purchasing or lending. The following are examples of government support for different markets:

1. **Agriculture.** Farmers rely on US Department of Agriculture (USDA) subsidies to reduce the risks of harvest weather, crop failure and market disruptions. They also rely on standardized USDA Farm Loans to buy and grow the nation's farms.[135]

2. **Banking.** Depository banks borrow at extremely low interest from the Federal Reserve to ease the management of their liquidity and loan repayment performance risks.[136]

3. **Community Development.** Community development financial institutions (CDFIs) rely on the US Treasury to seed funding of businesses and real estate development in target neighborhoods.[137]

4. **Energy.** From mining rights leased on federal lands to favorable tax treatment for capital investments, federal support for the oil, coal, natural gas and other energy providers has been instrumental.

5. **Healthcare.** The federal government insures and operates portions of the nation's healthcare capacity through Medicaid, Medicare, TriCare (formerly known as the DoD Military Health System's Civilian Health and Medical Program of the Uniformed Services) and the Veterans Health Administration.

6. **Housing.** Through the Federal Housing Administration (FHA), the government insures mortgages for the construction and expansion of healthcare facilities, ranging from large teaching institutions to small, rural, critical access hospitals.[138] The housing industry, home buyers, rent-subsidized tenants, banks, and the housing finance industry rely on standardized loans and loan guarantees from the Federal Housing Administration (FHA), Federal National Mortgage Association (Fannie Mae), Federal Home Loan Mortgage Corporation (Freddie Mac), and their participating lenders.[139]

7. **Education.** Universities and university students rely on standardized student loans from the US Department of Education's federal grants and loans, as well as private loans marketed via the Student Loan Marketing Association (Sallie Mae).[140]

8. **Exports.** Global corporate exporters and their foreign customers rely on loans guaranteed by the Export-Import Bank to reduce the interest to fund working capital and investments required to manufacture US products for export and to ensure foreign customer payments.[141]

9. **Small Business.** Small businesses have access to low-interest Small Business Administration (SBA) guaranteed loans and grants,[142] and bank loans required by Community Reinvestment Act (CRA) policy. [143]

10. **Transportation.** Transportation infrastructure, construction, and logistics companies rely on Federal Highway Administration (FHWA) loans, loan guarantees, and other assistance to support state and regional infrastructure development projects as a coherent, multimodal and intelligent national transportation system. [144]

Terrestrial history informed and compelled *federal financial engineering* to support and grow the nation's key industries - both established and on the horizon. Based on federal financial engineering, myriad private sector markets and their investors formed, relied on credit enhancement and implicit federal supports that increased investment and loan credit quality and channeled private capital in amounts that continue to leverage and dwarf the net out-of-pocket costs for such programs to the US Treasury. The United States can direct federal financial engineering to commercial space industries as a 21st century extension of its terrestrial economic and industrial policymaking, now that space is considered essential for critical infrastructure under the 2020 *National Space Policy*, although space has yet to be explicitly declared a critical infrastructure.[145]

ENDNOTES

[129] Chang, Ha-Joon. "Bad Samaritans: The Myth of Free Trade and the Secret History of Capitalism," 2008.

[130] Farm finance and farm equipment leasing arrangements through agriculture GSEs and price supports made affordable agricultural crops and the price of food. Automobiles became affordable with car finance and leasing arrangements that were standardized, pooled, rated, and resold to financial investors. Houses became affordable with mortgages and mortgage insurance that were standardized, pooled, rated, and resold to financial investors through housing finance GSEs.

[131] The SBA's role in financing small businesses was especially evident in distributing Paycheck Protection Program Loans, Economic Disaster Injury Loans, debt relief, and other stimulus during the 2020 COVID-19 Pandemic. SBA. "Coronavirus Relief Options," https://www.sba.gov/funding-programs/loans/coronavirus-relief-options.

[132] The "real economy" is contrasted with the financialized or virtual economy that is fueled by yields generated by trading stocks, bonds, cryptocurrencies, or other token of derivative ownership of yields on real economy assets. For a discussion of the real economy and its relationship for - good and bad - to financialization, see, Storm, Servaas. (February 13, 2018)."Financial Markets Have Taken Over the Economy. To Prevent Another Crisis, They Must Be Brought to Heel," https://www.ineteconomics.org/perspectives/blog/financial-markets-have-taken-over-the-economy-to-stop-the-next-crisis-they-must-be-brought-to-heel; Balder, John. (August 21, 2020). "Financialization: Explaining The Disconnect Between Financial Markets And The Real Economy," https://seekingalpha.com/article/4370056-financialization-explaining-disconnect-financial-markets-and-real-economy-part-3.

[133] Erwin, Sandra. "Ex-Im Bank to step up support for space industry challenged by Chinese competitors," Space News, July 9, 2020, https://spacenews.com/ex-im-bank-to-step-up-support-for-space-industry-challenged-by-chinese-competitors/.

[134] Ex-Im Bank was deauthorized by Congress and since December 2019 exists with a seven-year re-

authorization. See Henry, Caleb. “Ex-Im Bank gets seven-year extension,” Space News, December 21, 2019, https://spacenews.com/ex-im-bank-gets-seven-year-extension/.

[135] US Department of Agriculture. Price Support Programs, https://www.fsa.usda.gov/programs-and-services/price-support/Index and Farm Loan Programs, https://www.fsa.usda.gov/programs-and-services/farm-loan-programs/index.

[136] Board of Governors of the Federal Reserve System. Credit and Liquidity Programs and the Balance Sheet: Lending to Depository Institutions, https://www.federalreserve.gov/monetarypolicy/bst_lendingdepository.htm.

[137] US Department of the Treasury. Community Development Financial Institutions Fund, https://www.cdfifund.gov/about/Pages/default.aspx.

[138] US Department of Housing and Urban Development. Federal Housing Administration, Office of Hospital Facilities, https://www.hud.gov/federal_housing_administration/healthcare_facilities/section_242.

[139] US Department of Housing & Urban Development. Federal Housing Administration: Our History, https://www.hud.gov/program_offices/housing/fhahistory, Federal Housing Finance Agency, A Brief History of the Housing Government-Sponsored Enterprises, https://www.fhfaoig.gov/Content/Files/History%20of%20the%20Government%20Sponsored%20Enterprises.pdf; Fannie Mae. The Path of Progress: Our History, http://www.fanniemae.com/portal/about-fm/fannie-mae-history.html;

[140] US Department of the Treasury. Lessons Learned from the Privatization of Sallie Mae, https://www.treasury.gov/about/organizational-structure/offices/Documents/SallieMaePrivatizationReport.pdf; Sallie Mae Bank is operated by SLM Corporation, as explained in the SLM Corporation’s Form 10-K for 2017 filed with the US Securities and Exchange Commission, Company History, at page 3, https://www.salliemae.com/assets/investors/shareholder/annual-reports/SLM_Corp_2017_Form_10-K_2.23.18.pdf

[141] US Congress. Export-Import Bank of the United States, 12 USC §§635 - 635i-9, https://uscode.house.gov/view.xhtml?path=/prelim@title12/chapter6A&edition=prelim.

[142] US Small Business Administration. Funding Programs, https://www.sba.gov/funding-programs

[143] US Department of the Treasury. Office of the Comptroller of the Currency, Federal Reserve Board of Governors & Federal Deposit Insurance Corporation, Community Reinvestment Act; Interagency Questions and Answers Regarding Community Reinvestment; Guidance (Federal Register Vol. 81. No. 142 - July 25, 2016), 12 CFR Part 345, https://www.govinfo.gov/content/pkg/FR-2016-07-25/pdf/2016-16693.pdf.

[144] US Department of Transportation. Federal Highway Administration, Federal Credit Assistance Tools, https://www.fhwa.dot.gov/ipd/finance/tools_programs/federal_credit_assistance/.

[145] United States. National Space Policy of the United States of America. Washington, DC: Executive Office of the President of the U.S., December 9, 2020, https:// https://www.whitehouse.gov/wp-content/uploads/2020/12/National-Space-Policy.pdf.

9. CRITICAL INFRASTRUCTURE INDUSTRIES NEED FINANCIAL INFRASTRUCTURE

What Motivates Space Infrastructure Investors?

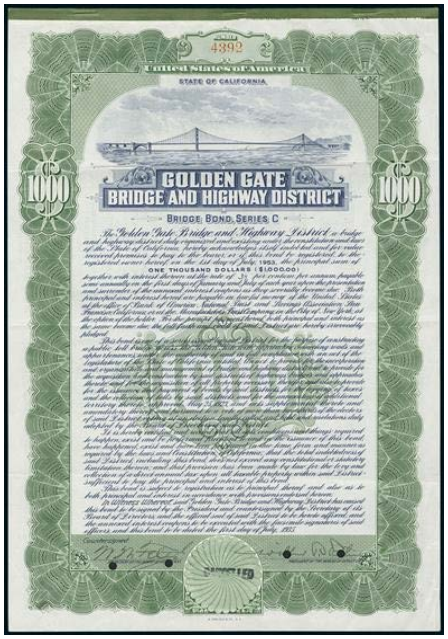
"Industrial and scientific development in the void of space that surrounds our delicate planet will help us carry on living on Earth over the next century. Satellites already deliver information (through agricultural weather satellites and the GPS system) that provides the extra margin of food that keeps nearly a billion people a year from starving. Today's generation has the technological ability to do more industrial work up there, providing communications, advanced science and even, potentially, solar power and [computer] server farms in space - thus taking CO2-intensive industry out of the atmosphere. The challenge is to get the technology up there in a safe, reliable and cheap way with minimal environmental impact. Non-reusable rockets launched from the ground based on designs from the 1940s are not the answer. It will come from the private sector working with - and independent of - agencies like NASA to bring new materials and technologies into space."[146]

Sir Richard Branson, CEO/Founder Virgin Galactic, 2010

The United States must invest - and have the financial engineering tools for private financial markets to invest - in US critical capabilities especially across all civil, commercial, and national space lines of effort. Space will be a key resource for the Earth's economic development and the enhancement of people's lives for the next decades and even centuries.

In turn, building physical and digital infrastructure to support the assets, goods and services of the space economy that the Earth relies on will span decades and require patient capital: financing from investors with long time horizons.

1930: Innovative Thinking in a 40-year Timeframe Funded the Golden Gate Bridge



In the public sector, bridges, highways, air and sea ports, hospitals, railroads, and other regional infrastructure became affordable through project finance bonds issued by various states, counties, and local government entities. They also relied on credit enhancement through pledges of their tolls and other revenues, federal transportation infrastructure funding, and private sector credit risk insurance.

Lessons learned can be drawn from how infrastructure finance bonds work to span the project's useful life. In November 1930, Wall Street banks were climbing out of the Great Depression. Having been spurned by the mainstream bankers, San Francisco and five surrounding county governments formed a special district under California law to issue $35 million in bonds to build the Golden Gate Bridge. The funding

was secured solely by the tolls to be collected from travel over the bridge throughout the bonds' 40-year lifespan, whereupon ownership of the bridge would transfer to the State of California.

The risks entailed in the massive Golden Gate Bridge project and its prospects for being built and generating toll revenue were in part mitigated when the founder of Bank of America, A. P. Giannini and the bank's president committed to underwrite the first tranche of bonds. The local government did not have the funds to pay the engineers and construction crews to design and build the bridge. The bondholders had those funds and wanted to earn a return (5% per year) on their funds. The bondholders were not bridge operators, but they knew the bridge would increase economic activity throughout the San Francisco Bay Area, creating affordable residential and commercial neighborhoods and standards of living. This in return increased the number of profitable investments and loans made throughout the region. The bonds were the financial engineering that transformed the technical risks (e.g., civil engineering of the bridge) and market risks (e.g., number of bridge riders), investor returns (5% per annum), asset type (physical infrastructure and annual toll collections), and maturity (i.e., 40 years) to match government economic development goals, current budgets, and investor horizons.[147]

2020: Space Bonds with Durations to Match Space Infrastructure

Every financial instrument traded through the financial system performs four functions: transforming risk, return, asset type, and maturity (time horizon). No one would fund long-lived terrestrial infrastructure (e.g., bridges, highways, hospitals, roads, or air and sea ports) primarily or exclusively through illiquid short-term venture capital, or issuing thinly-traded penny stock traded on over-the-counter (OTC) exchanges.[148]

Likewise, financing space infrastructure, requires infrastructure finance bonds, credit-enhancing guarantees, risk-transfer derivatives, and other long-maturity financial instruments that match capital to the lifecycle maturity of the assets and revenues serving as their collateral for repayment. Space infrastructure assets must serve dozens of nested value chains for years to come such as lunar navigation, habitat, refueling, and other assets for developing the lunar economy. Venture capital can start making space affordable, but space infrastructure requires larger amounts of capital committed for decades, in forms like bonds that long horizon investors can trade.

Across all areas of critical infrastructure built, operated, and owned by the private sector, federally-insured or federal-tax-advantaged bond finance plays an important role. Tax-exempt state and local development, hospital, school, transportation, and other bonds bear lower interest rates to reduce the burden on essential infrastructure projects. SBA-guaranteed loans allow a greater variety of small business entrepreneurs to grow jobs in the economy.

"Space Bonds" issued by space companies directly or through state or local economic development authorities could grow the portions of the regional economy focused on building, operating and owning assets as space infrastructure. A portion of the bonds

would carry federal credit enhancement in order to be credit rated as and constitute investment grade securities eligible to be held by banks, insurance companies and pension funds to meet appropriate risk-weighted portfolio diversification benchmarks and targets. In order to match interest and principal payments on the bonds to the lifecycle of revenue-generating space infrastructure assets, interest could be deferred on the bonds for the early years after issuance (e.g., Years 1 – 3), and then be rolled up into principal and repaid over the duration of the bonds until maturity (e.g., Years 4 – 25).

The imaginations and financial alchemy of the investment banks and bankers could be engaged via Requests for Information (RFIs) and Requests for Proposal (RFPs) to propose and justify stable structures for "space bond financial engineering" that prudently leverage – but do not abuse - appropriate federal credit enhancement and / or tax exempt treatment. Given how much US national security will depend on privately owned space infrastructure being durably operated and enhanced, the role of federal financial accommodations may prove to be both a bargain while diversifying the financial risk and sources of capital essential for long-term success.

ENDNOTES

[146] Gambino, Megan. "Richard Branson on Space Travel," Smithsonian Magazine, https://www.smithsonianmag.com/science-nature/richard-branson-on-space-travel-724917/

[147] Federal Highway Administration. "Fact Sheet: Golden Gate Bridge of 1937," https://www.fhwa.dot.gov/candc/factsheets/goldengatebridge.pdf; Museum of the City of San Francisco, "History of the Golden Gate Bridge Financing," http://www.sfmuseum.org/hist10/strauss.html; Golden Gate Highway & Transportation District, "History of the Golden Gate Bridge: Bond Measure Passes," https://www.goldengate.org/bridge/history-research/bridge-construction/bond-measure-passes/; Bank of America, "Building the Most Photographed Bridge in the World," https://about.bankofamerica.com/en-us/our-story/building-the-most-photographed-bridge.html#fbid=lRuFOZefF_S. Image of $1,000 Golden Gate Bridge and Highway Bond Series C issued July 1, 1933, https://www.the-saleroom.com/en-gb/auction-catalogues/spink-investphila/catalogue-id-srspinks10000/lot-0032b6f1-7862-454c-a56f-a409010a8d43.

[148] OTC Markets Group Inc., "Caveat Emptor Policy," https://www.otcmarkets.com/learn/caveat-emptor.

10. COMMODITIES EXCHANGES AS ENABLERS OF FINANCIAL INFRASTRUCTURE

The New Space Economy's Business Models will offer and be built from Commodity Goods and Services

"If you go back to when I started Amazon, all of the heavy-lifting infrastructure to support Amazon was already in place. We did not have to invent a remote payment system. It was already there. It was called the credit card… We did not have to invent transportation - there was this thing called the postal service. If we had had to deploy last-mile, it would've cost hundreds of billions of dollars. [There is a long list other industries that already existed - from PCs on every desk to internet deployment through fiber-optics that had been developed for long-distance telephones, that had to exist as 'commodities' as foundations on which Amazon could build its business model.]

"So when it comes to space, I see it as my job - I'm building infrastructure the hard way. I'm using my resources to put in heavy-lifting infrastructure, so the next generation of people can have a dynamic, entrepreneurial explosion into space."[149]

Jeff Bezos, CEO/Founder Blue Origin, 2016

Basic Commodities are Already Critical to the US Manufacturing Base

The United States must compete for global market share and leadership – currently dominated by China, Russia over terrestrial commodities – basic and manufactured – into the space economy:

> "For the decade spanning 2007–2016 … a subset of mineral commodities, including rare earth elements, platinum-group elements, cobalt, niobium, tantalum and tungsten, pose the greatest [supply risk] for the U.S. manufacturing sector. This subset includes commodities that have a high degree of production concentration in countries that may become unable or unwilling to supply to the United States, are mainly imported from other countries and are consumed in economically important manufacturing industries that may be less able to withstand a price shock that may result from a supply disruption."[150]

Delays in recognizing and responding to the great game competition for "space commodities" will erode US national security and limit the resources available to the future innovation base.

China's position has evolved into both a manufacturing and financial powerhouse. Seventy percent of the major metals used in consumer and industrial electronics are traded on Chinese commodities exchanges.[151] China's monetary power is strengthened because such commodities trades are denominated in China's currency, the yuan. Moreover, Chinese political leaders control each trade.

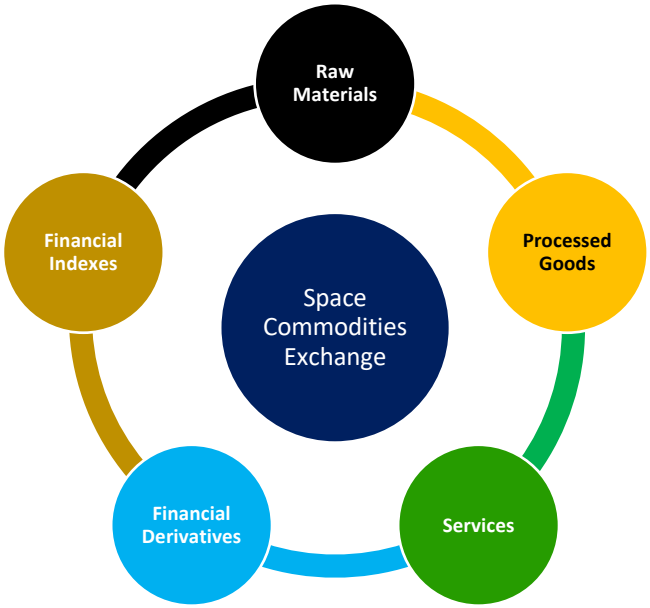
The United States should not be in the position of depending directly or indirectly, through its private sector contractors, on access to space commodities by buying commodities contracts from non-ally or partner but adversary-controlled exchanges. Doing so would not be a viable long-term space strategy because contracts in a centrally controlled economic system like China's could easily be canceled by government edict in the lead-up to any type of confrontation with the United States and its allies.

The Proven Role of Commodities Exchanges in Market-Based Economies

As already mentioned, an energy commodities exchange was established to define, trade, and transfer risk of supply and demand for the types of goods and services required to transact the various energy businesses.[152] Today, commodities exchanges also trade in financial instruments that de-risk agriculture, mining, manufacturing, carbon sequestrations, and related economic activities. The US financial market infrastructure must provide the means to define and trade the space commodities produced by that this new industry produces.

Designing a Space Commodities Exchange that Grows US Commercial Space Companies

Space commodities allow the space economy to evolve and rely on standardized definitions of the goods and services they produce and need to operate in, from and to space orbits and regions of interest.[153] Five categories of Space Commodities[154] have been proposed: raw materials, processed goods, services, financial derivatives, and financial indexes.[155]



These categories facilitate an infinite variety of balanced trades that help space companies and their customers diversify and reduce risk. Companies would assume the risks of designing and operating the technology, causing shareholders and bankers to conserve capital funds. The financial risks regarding whether the buyer will actually pay for the commodity good or service when it is delivered, as well as other risks such as collision, currency, political and others, are sold off and hedged via the Exchange.

For space companies, the Exchange would detail levels of demand for specific space commodities in Earth's orbit, near-Earth asteroids, cislunar, and beyond. Space companies would be permitted to earn cash flow via commodity contracts sold now for delivery in the future. It would also create a level playing field of Exchange Rules by which competitors agree to abide. The Exchange's operation produces a rules-based market certainty and transparency. That in turn encourages investors and lenders to fund - and buy off risk for - space companies that produce space commodities. When the demand for Exchange-traded commodities becomes more generic and the risks

tradable as commodities, the revenues produced become more certain and the marketplace attracts more investors and lenders. For space customers, the Exchange would allow for more open bidding, which drives better price/performance ratios. Furthermore, if a customer buys too much of a space commodity, it would allow for the re-sale of the commodity to achieve liquidity and flexibility in planning and adjusting future space operations.

For the US government, the Space Commodities Exchange would speed acquisition and assurance of the functional use of specific space commodities, in contrast to the delays incurred in navigating Federal Acquisition Regulations (FAR) and Defense Acquisition Regulations (DFAR). As is the case terrestrially, US government programs and missions may require space assets, goods, and services beyond the space commodities to be offered on the Exchange. However, the Exchange's commodities produced by commercially available dual-use technologies can be modified or augmented for specific government needs. This will both reduce the government's risk of bespoke technology development cycles and their maintenance budgets, improve the functionality, and interoperability of government technologies that depend on or seek to leverage ancillary space commodities such as data transfer bandwidth or energy.

The US financial regulatory system is among the most robust in the world. There have been missteps, but after each misstep the financial regulatory framework rebuilt itself stronger and among the most trustworthy financial centers. Financial innovation has started in the United States because bankers, institutional investors, traders, sovereign wealth funds, and the companies and industries they fund all trust that US regulatory rules will be consistently applied and will evolve to meet the technological and market needs of the national and global economy. US-regulated financial markets serve as an exponential multiplier of US "soft power."

The proposed Space Commodities Exchange would be formed and operated by a Board of Trade composed of space, manufacturing, finance, insurance, mining, and other members. These members would form various governing and technical committees to define the space commodities, the rules for trading them, and the numerous matters for the Exchange's operations pursuant to its rulebook as a Commodity Futures Trading Commission (CFTC) regulated Designated Contracts Market (DCM). The Exchange would create a public–private collaboration to serve as permanent financial infrastructure for US commercialization of the space economy.

A Space Commodities Exchange would be accepted among investors and users if the initial demand for the underlying commodities (e.g., raw materials, processed materials, services, derivatives and indexes) can be soundly established. One mechanism to "prime the pump" and kick-start a vibrant space commodities exchange would be to tie one or more US strategic reserves to these space commodities. For instance, a stated US demand to fill strategic reserves of water, propellants, metals, and minerals at various locations in cislunar space by certain dates would provide a transparent floor for potential market demand in terms of amounts, pricing, and timing. The same could be said of a range of services that the US government will need to support the USSF, NASA, and space priorities over time.

ENDNOTES

[149] Knapp, Alex. “Jeff Bezos' Space Plan: Building Infrastructure For The Next Generation,” Forbes, June 1, 2016, https://www.forbes.com/sites/alexknapp/2016/06/01/jeff-bezos-space-plan-building-infrastructure-for-the-next-generation/#3b9192462b7c

[150] Nassar et al. 2020. “Evaluating the mineral commodity supply risk of the U.S. manufacturing sector.” Science Advances. February 21, 2020.), DOI: 10.1126/sciadv.aay8647

[151] China, Russia, or other nations could create their own space commodities exchanges.

[152] Nearly every new economic and geopolitical era from the Old World to the New World required a commodities-like exchange. First commodities exchanges dealt in agricultural goods. A buyer of California oranges in New York would want to know the type, quality, and quantity of oranges they would receive. The Transcontinental Railroad could transport the oranges, but defining the types of oranges and the trading unit quantity and size, as well as the contract terms for arranging buyer obligations to pay and seller obligations to deliver, needed an exam. The same exchange functions were needed for the metals mined in California and across the United States.

[153] Space interoperability is more than a “nice to have,” it is a “must have.” Interoperability is needed across USSF and DoD space-dependent assets and services to pool purchasing power, reduce obsolescence and improve the multi-mission nature of orbital and cislunar modular platforms.

Imagine needing to refuel on the Moon or in lunar orbit. Should there be only one supplier with a unit nozzle charging whatever the emergency would allow? Imagine mining for lunar ice to be processed into water, oxygen, and hydrogen. How would an investor or lender estimate the demand for such lunar commodities in order to match the terms of their investment’s return or the loans debt payments to the timing of the miner’s or refiner’s revenues?

[154] Within each bucket are a wide range of goods, services, and risks traded and defined to be most relevant by various communities of expert buyers, sellers, and investors within the space economy. A kilogram of lunar rock containing rare earth minerals at a certain depth and estimated resource yield might be a Raw Material space commodity. The refined lunar mineral from the rock of various purities for use on the Moon might be Processed Good space commodities. Launch of a kilogram of inanimate cargo - akin to a FedEx box in standardized volume and weight - might be a Services space commodity, used along with a cluster of other space commodities like imagery, navigation, logistics, and space debris removal. A financial swap whereby one party bets that a lunar mining mission will produce refinable deposits or that a particular launch will occur would constitute a Financial Derivative space commodity. A basket indexed to space commodities relating to activities in Low Earth Orbit, Lunar Orbit, or Near Asteroid Orbit would constitute a Financial Index space commodity.

[155] The design for the Space Commodities Exchange presented in this Section reflects research and proposals presented in Cahan, Bruce, Marboe, Irmgard & Roedel, Henning, Outer Frontiers of Banking: Financing Space Explorers and Safeguarding Terrestrial Finance (New Space Volume 4 Number 4 – December 1, 2016), https://doi.org/10.1089/space.2016.0010; Cahan, Bruce, Pittman, R. Bruce, Cooper, Sarah & Cumbers, John, Space Commodities Futures Trading Exchange: Adapting Terrestrial Market Mechanisms to Grow a Sustainable Space Economy (New Space Volume 6 Number 3 – September 1, 2018), https://doi.org/10.1089/space.2017.0047; and Cahan, Bruce & Locke, Timothy, Space Commodities in Service of National Security (2018 AIAA SPACE and Astronautics Forum and Exposition – September 2018), https://arc.aiaa.org/doi/abs/10.2514/6.2018-5150.

11. VISIONARY POLICIES AND ACTIONS REQUIRED TO SECURE US SPACE LEADERSHIP IN THE ECONOMIC GREAT GAME

Importance of Multi-Administration Visions, Strategies, and Policies

"The United States will create an environment that energizes our industry to create innovative commercial approaches that will carry and sustain our next generation of explorers and entrepreneurs on the Moon and then on to Mars and beyond. Our way of life on Earth is greatly enhanced by space and the United States acknowledges the importance of space to the advancement of all humanity. The United States will lead and strengthen enduring international partnerships to preserve and sustain space for future activity and so that all nations and all people can benefit from space and improve our way of living on Earth and in space." [156]

US National Space Policy (2020)

"The world is entering a new and exciting era for space. In this century space will continue to grow rapidly as a major element of overall human civil, commercial and military actions and as an element of any country's national power. This new era offers promise and hazards to the United States. Continued leadership in space will anchor US national power. Loss of leadership will put the US global strategic interests at risk. Key to any future with the US as a space leader requires a vibrant, innovative robust US space industrial base."[157]

State of the Space Industrial Base (2020)

Space will become "a significant engine of national political, economic and military power." [158] In order to ensure that space remains a priority domain, "the United States must commit to having a military force structure that can defend this international space order and defend American space interests, to include American space settlements and commerce."[159] ***The United States can either prepare and position itself to shape a future with American strategic leadership in space, or resign ourselves to second-class status and ask ourselves why America never made the necessary reforms.***[160] Further progress is necessary to retain America's global competitive advantage and ensure the resilience of the US commercial space industry. In this renewed era of great power competition, the US government must develop a coherent and enduring economic and national security policy regime that coordinates its economic and strategic policy tools to promote and incentivize the growth and innovation of the US space industrial base and America's trusted allies and partners. Such a holistic policy regime empowers the various US government agencies to deploy to their fullest extent all the traditional and emerging instruments of national power. Various US government, industry, and academic space stakeholders have identified the following recommendations for relevant federal offices of primary responsibility (OPRs).[161]

Craft a "North-Star," Top-Level National Space Vision and Strategy

The industrial foundation of US space leadership must adapt to the future operating environment in space. To adapt, the United States must create and execute an integrated, comprehensive national space vision and strategy. That strategy must fuse

national security, civil, and commercial space efforts on a day-to-day basis. The United States should develop a guiding 2060 National Space Vision for long-term space industrialization and national space development to catalyze whole-of-nation efforts and enable the United States to compete successfully, now and into the future. By driving a whole-of-nation 2060 National Space Vision across a host of federal department and agency-specific actions, all space strategies and polices can be synchronized, procurements efforts across the government can be scaled and integrated, diverse perspectives leveraged, and unity-of-effort leveraged. This Vision can be best crafted by a Presidential appointed National Space Enterprise Task Force comprised of the US interagency, state, local, and private representatives. **(OPRs: NSpC, NSC, NEC, OSTP, OTMP)**

Organize Federal Space Enterprise for the Future

While the NSpC is a hub for expressing the desired policies of the Executive Office of the President (EOP), future presidential administrations may reassign or reorganize the handful of NSpC staffers, dispersing their institutional knowledge of space interdependencies. In the interim, the nation's space policies, planning, budgeting, programmatic needs, and procurement activities grow unaligned. ***The Executive Branch lacks a standing coordinating interagency body for all space matters to fuse diverse perspectives and rapidly resolve issues opportunely and tactically***. Subsets of those questions and the responsible federal managers empowered to ask them are strewn across the federal bureaucracy. Meanwhile, US global economic power is outpaced by global competitors and great power adversaries leapfrogging US siloed expertise, that is constrained to only informal cooperative arrangements that are not integrated or cross-validating across the federal government.

Government bureaucracy and lag times must be reduced for space to serve as a priority domain. Federal departments and agencies must visualize and resolve their issues among themselves via a coordinated process in real-time. Through this coordinating body, federal missions, programs, and functions that rely on space as critical infrastructure can invest more wisely to ensure expediency, efficiency, and long-range effectiveness. Rather than escalate space topics of mutual advantage or concern into the lengthy, multi-layered interagency White House-led review process, policy, and budget elements could be timely raised and adequately resolved at the lowest levels of collaborative discourse by a coordinating interagency space body that cuts through bureaucratic silos and streamlines the layers of review.

Establish a National Space Enterprise Task Force

In order to implement a multi-Administration National Space Vision, various US government, industry, and academic space stakeholders have identified the need for an all-Space matters executive agent that is horizontally wide and vertically flat to serve as a permanent space-focused interagency body. The body would fuse diverse perspectives from across the federal government, state, and local authorities and private-sector space stakeholders. The detailees working together in an existing

government facility would allow the body to address strategic space issues to reduce bureaucratic lag times and interagency disagreements[162] that do not prioritize the space domain.

A National Space Enterprise Task Force that can evolve into a permanent National Space Enterprise Center addresses these concerns.[163] As the national-level executive agent for all-Space, the National Space Task Force would develop a "north-star," top-level 2060 National Space Vision and strategy to sustain US space superiority by integrating and synchronizing actions across the whole of government and exercising all necessary instruments of national power. The National Space Enterprise Center would follow a model similar to but leaner and with less interagency redundancies than the National Counterintelligence and Security Center or the National Counterterrorism Center.[164] It would serve as an interagency coordinating body, fusing diverse perspectives and rapidly resolving space-related issues across participating departments and agencies seamlessly on a day-to-day basis and in unity of effort to meet the 2060 National Space Vision. Integration and interdependency of space capabilities permit and enhance assimilating shared technologies, talents, investments, and discoveries. **(OPRs: NSpC, NSC, NEC, OTMP)**

Declare Space as a Separate Critical Infrastructure Domain

The US government must streamline and coordinate space as a separate critical infrastructure domain by utilizing an integrated whole-of-nation approach. In 2013, Presidential Policy Directive-21 declared various industrial sectors as "critical infrastructure," but did not anticipate how rapidly "space" would evolved into "critical infrastructure" and domain of economic activity.[165] The United States will be left vulnerable if it delays or fails to ask, debate and answer strategic questions about how, when, and where to co-invest in and de-risk space activities that serve as critical infrastructure or as essential network assets and functions for previously declared critical infrastructures. **(OPRs: NSpC, NSC, NEC, OSTP, OTMP, DHS, DoD)**

Create the Financial Tools to Grow the New Space Commercial Ecosystem

The United States must promote the development of new economic, financial, and market tools to exert "soft power" by increasing American commercial space activities and supporting the growth of American space companies. The tools should specifically include the following:

Create a Space Commodities Exchange. Space commodities allow the space economy to evolve and rely on standardized definitions of the goods and services they produce and need to operate in, from and to space orbits and regions of interest. The Exchange would reveal detailed levels of demand for specific space commodities in Earth orbit, near-Earth asteroids, cislunar, and beyond. Space companies would be permitted to earn cash flow via commodity contracts sold now for delivery in the future and would create a level playing field of Exchange Member Rules by which competitors agree to abide. The Exchange would allow for more open bidding that would drive better

price/performance ratios for government and private sector users. Furthermore, if a customer were to buy too much of a given space commodity, the Exchange would allow for the re-sale of the commodity to achieve liquidity and flexibility in planning and adjusting future space operations. The Exchange would speed government acquisition of generic, commercial off the-shelf (COTS) space commodities at lower technology readiness and reliability risk to ensure the functional use of specific space commodities, in contrast to the delays incurred in navigating FAR and DFAR. The National Space Council (NSpC) and the National Economic Council should direct the Secretary of Commerce, the CFTC Chair and other relevant experts to identify the necessary steps the US government must take to enable the creation of a Space Commodities Exchange and to report back to the NSpC on the way ahead. The Exchange will, among other things, require the US government to better understand and forecast its aggregate demand for space-based commodities. **(OPRs: NSpC, NEC, DoC, CFTC)**

Develop Federal, State, and Municipal Bond Markets to Invest in Space Infrastructure. The federal government could spur the development of a market for "space bonds" through various credit enhancement strategies. Those strategies could include federal partial guarantees of debt service payments, federal "take or pay" leasing or other arrangements to utilize the services that the assets financed by the bonds provide, federal income tax exclusion or deductibility for interest received on the space bonds and eligibility of space bonds to be counted toward specific regulatory reserve ratios for banks, insurance companies, and other financial institutions. Combining long-lived space infrastructure finance tools with the early-stage investments that the federal government makes in promising space technologies and business models would begin to close gaps for space companies that outgrow R&D grant, prototyping, and VC funding. It would also aim to build the necessary reliable assets, products and services for US commercialization of space. The United States could lead in offering the "financial engineering" that provides new companies with the necessary capital to grow. The United States would become a major hub for financeable space innovations and the people and companies that build them would become the key players. The United States should also jointly establish a strategy for leveraging public and private bond markets to finance space infrastructure. In consultation with the Securities and Exchange Commission and state and local officials, financial market actors such as investment banks, investors, pension and mutual funds, rating agencies, and others can make space-based infrastructure bonds an attractive asset class. **(OPRs: Treasury, DoC, DFC, SBA)**

Reform Small Business Innovation Research (SBIR) to be More Accessible to Business. DoD, NASA, National Science Foundation and other relevant executive branch entities, in consultation with the US Congress, should increase the share of the more than $2 billion SBIR program's grants for commercial space technology companies. Importantly, the SBIR program should be reformed to streamline the application process and include shorter award cycles, larger dollar amounts and less prescriptive topic selection. **(OPRs: NSpC, NEC, DoD, NSF, Congress)**

Rethink and Revamp US Procurement Policies to Level the Playing Field for US Commercial Space Companies

The US government procurement mechanisms, dating from the Industrial Age, never accounted for the space domain. They enshrine legacy product, services and contractors through siloed descriptions of what the government wants to buy without considering its practical use alongside other procurements. They reject innovators' viable new business models and hamper US government collaboration with startups and their talented progeny. This leaves a blind spot and makes it difficult to predict what the US government will want and need to buy for the specific tasks and operations it chooses to conduct in space, on the Moon, or elsewhere. Predicting the probability of what isolated or mix of government procurements will be funded by the annual uncertainties and brinksmanship of the President's budget and Congressional appropriations poses risks for the US commercial space that quasi-public companies in centrally-planned economies do not face. Also, there is no existing federal interagency space infrastructure and services needs working group through which to align and improve federal investments in multi-use space technologies and the services that federal contractors are developing in isolation or that the commercial space economy is developing generically.

VC financing based on the US government as the first prime customer fails to grow US domestic commercial space customers and supply chains, once limited government seed grants and prototyping contracts expire. Macroeconomic scenarios have yet to provide quantitative proof because there are no built models to reflect what the US deficit and federal budget would save by enabling commercial space to be fully financed now via private sector sources, in contrast with delaying such financial innovations.

The US government accounts for a crucial share of US space market demand and its role as a first mover drives technological development and future commercial market growth. However, the US government does not have a full accounting or forecast of its space-based purchases and future demand across all agencies and departments across the infrastructure planning horizon of 2020 - 2060.[166] This information gap limits the US government's ability to leverage its buying power to drive down costs and transmit a clear and predictable demand signal to private sector companies and their investors. The US government should publish an ongoing government-wide survey of its space needs to add transparency and mitigate government uncertainty and opaqueness risks in the marketplace.[167]

Aggregate Current and Future US Government Market Demand. The US government should conduct a federal inventory of existing and future US government demand for space-related goods and services and space-based commodities in the near-, mid-, and long-term. The government should identify common purchases and develop a centralized process for government purchases of space-related products and services. They should present the results in a format comprehensible to private sector participants at appropriate security classification levels. **(OPRs: OSTP and NSpC/NSC, DoD, OMB, DoC, NASA, FFRDC)**

Create a Framework for Like-Minded Allies and Partners

In order to leverage US soft power, the US must shape the future-operating environment in Space by promoting international norms and standards, property rights in space, and develop a framework for maintaining peace, generating wealth, and securing allies and partners. The United States needs to permanently level the playing field for allies and partners to build their companies and abide by shared norms and rules so that the space economy reflects US market principles. In doing so, foreign markets will be made accessible and foreign demand for, US space companies' products and services will ensure US companies longevity and supply chains through innovative economic policymaking and financial tools. Great power competition is as much about economics as it is about geopolitics. The United States is undermined by global competitors and foreign adversaries that target American allies and partners through offers of joint participation in platforms such as China's Belt and Road Initiative that build and finance economies, infrastructure, wealth, and now space endeavors. In response to this challenge, the United States must provide meaningful alternatives for US-sympathetic nations that move beyond space exploration or military cooperation and provide a path toward shared prosperity from an expanded space economy. **(OPRs: NSC, NEC, NSpC, State, DoD, Treasury, DoC, NASA, EXIM)**

***Establish Private Property Rights in Space*.** Private sector ownership rights for space-based assets, as well as the legal means to create, transfer, license, and hypothecate them are essential if US market principles are to apply and be enforceable for space entrepreneurs and their investors, lenders, and customers. The inefficiencies or ambiguities of law and regulation today put the United States at risk, ignore opportunities to collaborate with America's allies and partners, hamstring US corporations with outdated technology transfer restrictions, and starve the most nimble, efficient, and innovative new American companies of the capital they need to create revolutionary new technologies and business models. **(OPRs: NSC, NSpC, NEC, DoJ, State, DoD, NASA)**

Rewrite US Rules to Leverage Foreign Collaborations. The US government must rethink and improve information sharing to streamline and safeguard the export control review process that ensures both America's national security and global economic competitiveness. All federal departments and agencies should expand domestic information sharing and align the export control review processes across the US government. They should also establish a "standard review clock" for all applications and an expedited "priority review" for foreign allies in order to speed up existing Departments of Commerce and State efforts to move technologies from the US Munitions List (USML) to the Commerce Control List (CCL). All federal departments and agencies, including NASA, must have direct terminal access to one unified common database for making determinations on US export control. Export control determination should draw upon at least one other federal department or agency's expertise before rendering a final approval to ensure the fullest compliance with export controls. Access to this database should also be made available to the US intelligence and law enforcement communities to support counterintelligence and counterespionage

activities and prevent inadvertent foreign military sales to adversaries. This expansion of information sharing and tightening of the review processes across the government to deal with compliance and regulations would give confidence to move most items from the USML. **(OPRs: NSC, NSpC, State)**

Improve Supply Chain Transparency and Traceability to Detect Foreign Adversaries' and Global Competitors' State-Owned Companies

Supply chain transparency and traceability are key elements needed to level the playing field for US space companies and implement the US-led market economic principle of product quality, safety, and liability for failure that corporations and their banks, investors, and contractors face. Therefore, foreign manipulation and irresponsible use of supply chains raise concerns at the highest levels of the US government. Complex global supply chains introduce a high degree of risk to domestic companies and, in turn, national security space end users. The United States, along with its allies and partners, must understand the origin and assembly process of critical components for complex space-based technologies to prevent malicious or counterfeit parts.[168] Supply chain hygiene is crucial to the development of space technologies for US national security and commercial purposes.

Government procurement and global supply chain managers rely on a vast array of data to ascertain suppliers' compliance with legal requirements (e.g., anti-money laundering, counter-terrorist funding, and anti-corruption) and best practices (e.g., environmental, human rights, fair labor, and other development goals that promote US civil society policies). However, no company, bank, or investor group regardless of how large or global has the resources to conduct the due diligence needed to ascertain the direct ownership, indirect control and other undue influences that a foreign country may use to unfairly and potentially illegally gain access to sensitive proprietary commercial intellectual property. For the space economy to grow, such unfair and unaccountable foreign practices pose a grave danger to US national security and commercial investments terrestrially and beyond.[169] Indeed, even if a private US company did its proper due diligence and ended up unwittingly being a channel through which foreign adversaries obtained intellectual property or other assets, the US national security would have been compromised. Furthermore, the company's brand, government, and supply chain contract capacity to raise capital and ability to retain talented human capital might be unduly tarnished or destroyed.

Precedents for specialized collaborative space intellectual property and supply chain law enforcement oversight include a range of countries and precedent organizations, such as:

- **The International Criminal Police Organization (INTERPOL)** across 194 countries coordinates the investigatory, law enforcement and prosecution of international criminal activities.[170]
- **The Financial Activities Task Force** (**FATF**) across 39 countries facilitates international efforts to combat money laundering and counter-terrorist funding, as well as the compliance of global banking and financial systems with such laws.[171]

- **The Five Eyes Partnership for Intelligence Oversight**[172] across five allied countries to improve the sharing of intelligence outputs and the actions taken based on those outputs. The US Five Eyes Intelligence Oversight and Review Council[173] asserts and represents US interests within the Five Eyes Partnership.

The envisioned information-sharing collaborative agency would serve multiple purposes, including:

1. Protecting US space suppliers, investors, lenders, employees, and their foreign partners from unwittingly becoming channels for threats to US national security interests in space or terrestrially.
2. Analyzing queries to the database to crowdsource industry concerns or reveal state-actor hacks intended to focus attention on a particular company or individual, thus yielding a new set of actionable intelligence.
3. Scoring foreign national contributions to the database for credibility and timeliness, thus enhancing international cooperation and national improvements in government law enforcement, anti-corruption and transparency.
4. Generating a digitally-authenticated time-stamped certificate of inquiry as *prima facie* evidence of safe harbor due diligence to speed up international collaborations, teamwork, financing, and prudent supply chain management to develop the space economy using open and transparent market rules.

Reward Supply Chain Transparency. The US government should also create a golden accreditation certificate process to ensure durable space supply chain accountability and to reward firms that demonstrate supply chain hygiene. The government should do so by illuminating a required number of layers in the supply chain with front-of-the-line passes in the contracting process. This effort should be coupled with development and adoption within the federal government and contracting firms of new critical and emerging technologies such as blockchain or distributed ledgers for digital identity and supply chain management. **(OPRs: NSpC, NSC, OSTP, DoD, DoC, DOT)**

Align Counterintelligence and Counterespionage Efforts. These efforts also necessitate that the US government assess the adequacy in training, capability, and development areas of all counterintelligence offices and intelligence cadre assigned to national security roles for civil and commercial space and tasked with tracking space supply chains and dual-use technologies. **(OPRs: NSC, ODNI, DSCA, FBI, DoC)**

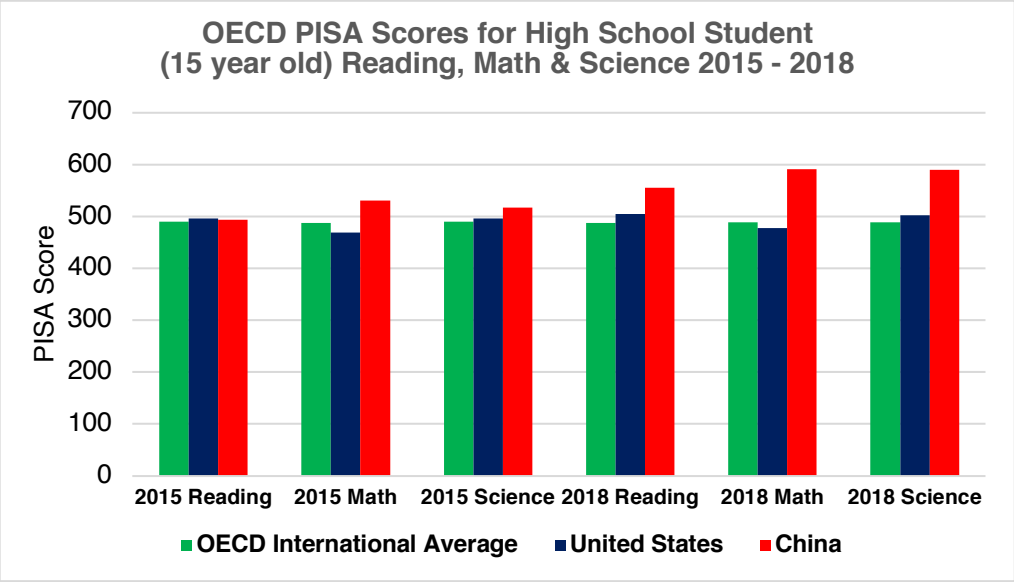
Formalize an INTERPOL, FATF, or Five Eyes–Like Information Sharing Partnership. The United States should pursue a Five Eyes-like collaborative agreement with allies and partners to develop a common standard. The agreement should formalize information sharing on space supply chain providers and their principals and funders to support counterintelligence activities and training. Such knowledge can assure that the commercial space market develops as a “level playing field” for free and open global competition in the space economy, cognizant of relevant national security concerns and realities. Global competitors and foreign adversaries may be pursuing their sovereign interests under applicable United Nations space treaties. However, the

informational evidence of these actions is scattered, unorganized, and security classified. This makes it unclear who did what to whom when, where, and how. The United States and its allies and partners could act together to let the public financial markets and other media know what happened. Transparency serves to contain misbehavior and justifies coordinated US-led actions in response. **(OPRs: DoC, DoS, DoD, ODNI, NASA, FBI)**

Assess Impact of Committee on Foreign Investment in the United States (CFIUS). The US government should also undertake an assessment of findings, challenges and recommendations of the impact of CFIUS on the space sector. **(OPRs: Treasury)**

Educate and Retain Human Talent and Capital to Work on A US Space Vision

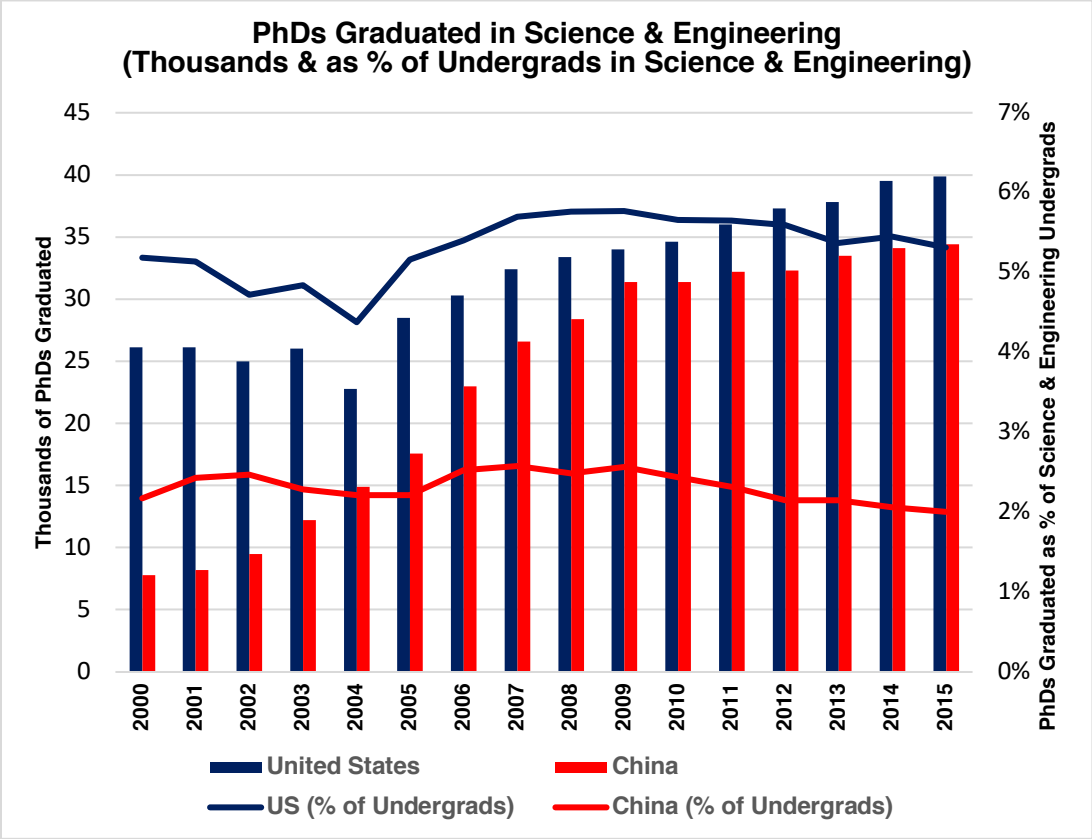
The United States' greatest assets are its people's curiosity, ingenuity, knowledge, diversity, and resolve. The country's people and their talents - far more than national political, financial, or technological resources - enable the United States to prosper as a great power. At the moment, space provides value because it allows people to create, distribute, and sell data. In the future, as space becomes commercialized, industrialized, and as essential tool of national security and human rights enforcement, highly skilled human capital needs to be educated and assured career advancement.



The United States graduates far too few science, technology, engineering, and math (STEM) professionals to effectively compete globally in the long run. The foundations for STEM education begin early in elementary, middle, and high school with reading, math and science, in which the US has fallen behind China, as shown in the above chart.[174]

Of the US high school students who have the opportunity, talent, and resources to go to college and receive undergraduate science and engineering degrees, only a fraction have the passion and resources and find programs sufficient to graduate with doctoral degrees in science and engineering,[175] or to complete bachelors of science and masters degrees, or obtain vocational training in science and engineering fields. The systemic

US labor shortage in domestically sourcing STEM talent for the space industry and other technologically advanced industries compromises US national security and industrial base, as illustrated in the following chart.[176]



Current STEM personnel numbers do not meet the needs of expanded national space capabilities and the industrial base that provides those capabilities. If there are not enough qualified and skilled US persons to fill the required thousands of STEM jobs, then the United States must discuss alternative means to provide technical and scientific labor to America's space industry.

NASA's Artemis program will require an additional 10,000 STEM graduates over the next five years for its civil space needs alone. This does not include the human STEM talent needed to support the new USSF or the growing private commercial space sector. The space sector also competes for STEM talent with other high technology sectors. In addition to STEM, the industry will require non-STEM personnel knowledgeable about the space enterprise in a variety of supporting occupational fields such as financial engineering, economics, and law.

Filling human capital gaps in the dynamic US labor market will require a whole-of-government mobilization, including the following:

> ***Create University-Level Space Centers of Excellence***. The US Congress should consider creating Space Centers of Excellence at civilian universities, similar to the Intelligence Community Centers for Academic Excellence program. These Space Centers of Excellence will increase the pool of diverse STEM and

non-STEM job applicants to fill the shortage of the more than 10,000 jobs that space innovation is projected to require. **(OPRs: Congress)**

Leverage Federal Educational Grants and Forgivable Loans to Incentivize STEM. The Department of Education should leverage federal educational grants and loans to incentivize US students to enter and complete STEM fields of study. These fields are essential to the human capital workforce that will produce the intellectual property, know-how and technologies that are vital for national security and commercial space supremacy. (**OPRs: Domestic Policy Council, Department of Education)**

Establish the Space Corps of Engineers. The Department of the Air Force should provide the USSF with the necessary resources to establish a Space Corps of Engineers to primarily oversee space infrastructure within the United States and space-related work abroad. **(OPRs: DAF, USAF, USSF)**

ENDNOTES

[156] United States. National Space Policy of the United States of America. Washington, DC: Executive Office of the President of the U.S., December 9, 2020, https:// https://www.whitehouse.gov/wp-content/uploads/2020/12/National-Space-Policy.pdf

[157] SIB 2020 Report, page 58.

[158] Mozer, Joel. The Future of Space 2060 and Implications for U.S. Strategy: Report on the Space Futures Workshop. Air Force Space Command, September 5, 2019. 1-32.

[159] Ibid.

[160] Sadat, Mir. "Space Cooperation in an Age of Great Power Competition in the Indo-Pacific." Hudson Institute. 2019. https://www.youtube.com/watch?v=63B74CEbpsg

[161] OPR acronyms used herein are summarized in Appendix G.

[162] As often is the case for highly-specialized activities like space, government officials develop and tend to rely on a handful of private sector consultants and contractors. While this practice might reduce the government's and the government official's risk, it tends to exclude viable new strategies, ignore cross-domain interagency synergies and result in procurement activities that balloon simply because other agencies' parallel needs for space capabilities are not considered in formulating or awarding federal procurements. By creating a cross-agency sounding board for anticipated federal space needs, the "insiders' game" that captures and spends federal budgets on space capabilities can be cross-checked and made of value outside of the federal department or program that historically relied on and created a limited number of viable vendors.

[163] An interagency coordinating body for space would follow the precedent and the lessons learned in managing other complex challenges that require ongoing whole-of-government leadership and alignment with private sector stakeholders, such as HHS' National Health Security Strategy and its Implementation Plan, https://www.phe.gov/Preparedness/planning/authority/nhss/Documents/NHSS-Strategy-508.pdf, DHS' Cybersecurity & Infrastructure Security Agency, https://www.cisa.gov/, The Federal Geographic Data Committee, https://www.fgdc.gov/who-we-are/history#7, the National Wildfire Coordinating Group, https://www.nwcg.gov/, the National Counterintelligence and Security Center, https://www.dni.gov/index.php/ncsc-who-we-are or National Counterterrorism Center, https://www.dni.gov/index.php/nctc-who-we-are.

The operational difference between a "Center" and a "coordinating group" is meaningful. "Centers" typically have a detailed or permanent staff and resources dedicated to carry out defined inter-agency

coordination missions. “Coordinating groups” typically are ad-hoc arrangements, by interagency MOUs: Memorandums of Understanding or other mechanisms through which federal employees devote part-time efforts to coordination.

Space is a full-time, not a part-time, real-time challenge and merits a “Center” resourced for the task. Such a Center may be housed and administratively controlled by an Executive branch department or agency, but the Center should not be operationally controlled by any specific department or agency. The Center’s leaders should be considerate of the interagency process and the space priorities of the various departments and agencies.

[164] See other examples and discussion at footnote 163.

[165] United States. Presidential Policy Directive on Critical Infrastructure Security and Resilience. Washington D.C: Office of the Federal Register, National Archives and Records Administration. 12 February 2013, https://www.govinfo.gov/content/pkg/DCPD-201300092/html/DCPD-201300092.htm

[166] This proposal resembles how the Office of Management and Budget (OMB) annually receives covered agency reports on geospatial technology needs forecasts and the anticipated multi-year budget requests for geospatial data, systems and analytics. By analogy, with multiple agencies performing government functions in California for multiple purposes, it would make little sense for each agency and each program within each agency to map California from scratch without access to the geospatial data developed across the federal enterprise. The more regularly California data is developed in interoperable, secure, privacy-protected formats with metadata pedigrees for trustworthy re-use as part of the National Spatial Data Infrastructure, the better the holistic decision-making will be in coordinating the impacts and priorities of federal programs in the state. Having a pooled buying concept for federal needs in space will aggregate to a more reliable demand and produce a more multi-use set of space platforms and space commodities that will let the federal budget do more, sooner, for less overall costs and risk.

See OMB Circular A-16 Revised: Coordination of Geographic Information and Related Spatial Data Activities, August 19, 2002, https://www.whitehouse.gov/wp-content/uploads/2017/11/Circular-016.pdf; The Geospatial Data Act of 2018, P.L. 1`15-254 Title VII Subtitle F Sections 751 – 759C, https://www.congress.gov/115/plaws/publ254/PLAW-115publ254.pdf; Congressional Research Services. The Geospatial Data Act of 2018, October 22, 2018, https://crsreports.congress.gov/product/pdf/R/R45348

[167] Such a survey would resemble the activities supporting and the information developed via “OMB Circular A-16: Coordination of Geographic Information and Related Spatial Data Activities,” https://www.whitehouse.gov/wp-content/uploads/2017/11/Circular-016.pdf, whereby OMB OIRA with the assistance of federal agency CIOs and GIOs assesses federal program IT needs and plans so that the federal enterprise can create, combine and rely on interoperable geospatial and other datasets without relying upon legacy data formats, systems and their high maintenance costs that deny the US government the fast adaptability that private sector technology-dependent companies evolve. By analogy, see US General Accounting Office. (September 30, 1996). “Information Technology Investment: Agencies Can Improve Performance, Reduce Costs, and Minimize Risks,” https://www.gao.gov/products/aimd-96-64

[168] In order to resolve the problem of counterfeit or malicious parts, the space industry must take lessons from the aviation industry especially with regard to assuring component integrity and for tracking the manufacturing origin, method, pedigrees, and testing for commercial aircraft parts as well as when and how they were replaced.

[169] In order to promote national security and commercial trade, the US government needs to organize its supply chain intelligence relevant to the terrestrial and space economies in an online digital form, so anyone can

- search and ascertain which foreign companies, investors, banks and other market participants are on a “suspect entity or individual” list,

- receive an immutable digitally-signed record of the date and time when and what query was made, and
- use such digital inquiry record as *prima facie* evidence of non-culpability if thereafter the user is accused of violating US laws relating to trading with foreign governments or their nationals.

[170] INTERPOL. "Who We Are," https://www.interpol.int/en/Who-we-are/What-is-INTERPOL.

[171] FATF. "Members and Observers," https://www.fatf-gafi.org/about/membersandobservers/.

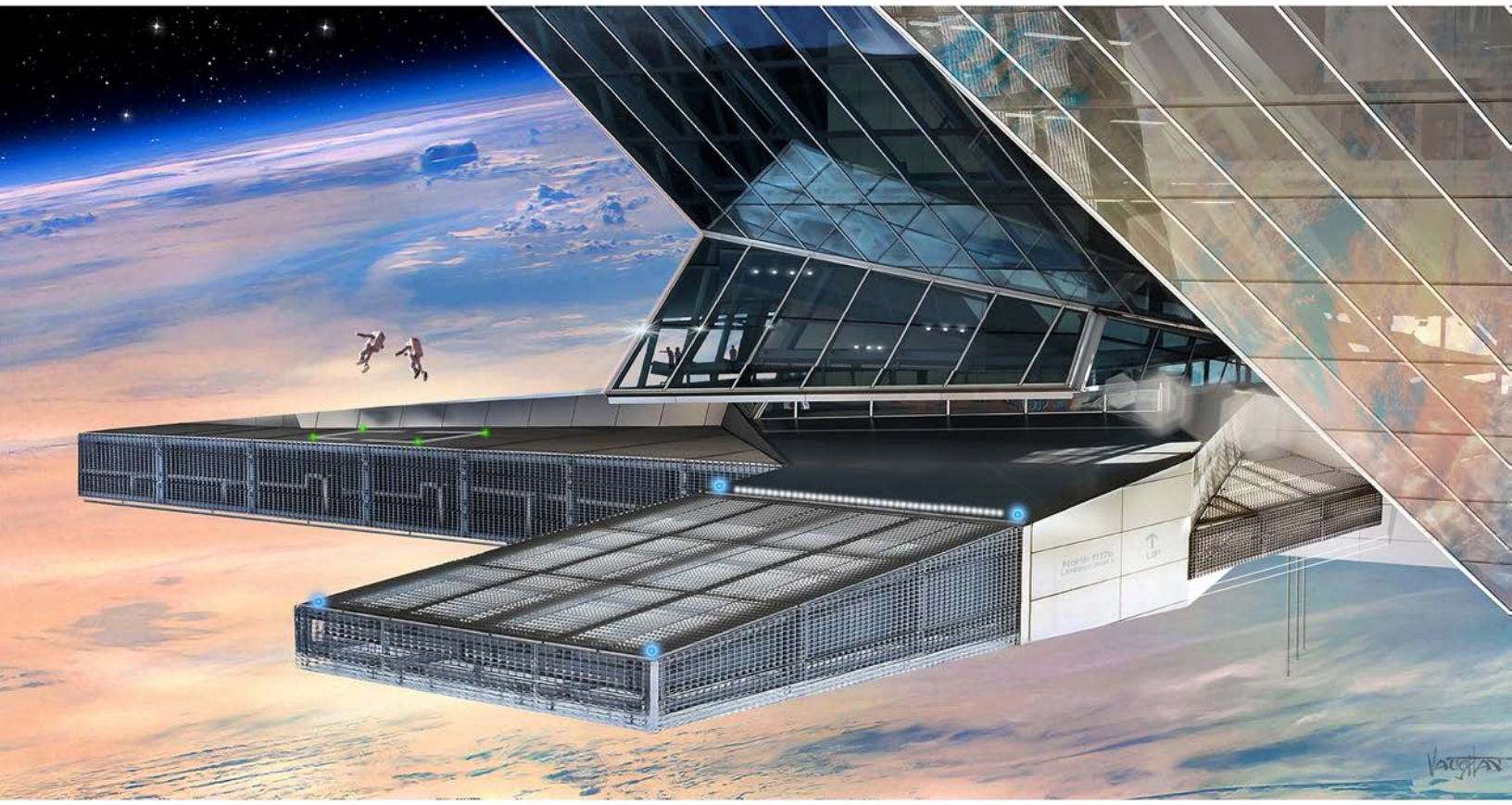
[172] Five Eyes. "Who We Are," https://www.dni.gov/index.php/who-we-are/organizations/enterprise-capacity/chco/chco-related-menus/chco-related-links/recruitment-and-outreach/217-about/organization/icig-pages/2660-icig-fiorc

[173] US Five Eyes Council. https://www.dni.gov/files/ICIG/Documents/Partnerships/FIORC/Signed FIORC Charter with Line.pdf

[174] Organization for Economic Cooperation and Development. Programme for International Student Assessment: 2018 Data Survey, https://pisadataexplorer.oecd.org/ide/idepisa/report.aspx

[175] National Science Foundation. The State of US Science and Engineering 2020, https://ncses.nsf.gov/pubs/nsb20201/u-s-and-global-education

[176] Ibid.



12. CONCLUSION

The First Space Race pushed US Leadership and Industry to Create the Future

"The exploration of space will go ahead, whether we join in it or not and it is one of the great adventures of all time and no nation which expects to be the leader of other nations can expect to stay behind in this race for space."

John F. Kennedy, 35th President of the United States, 1962[177]

"If we do not make the strong effort now, the time will soon be reached when the margin of control over space and over men's minds through space accomplishments will have swung so far on the Russian side that we will not be able to catch up, let alone assume leadership."

Lyndon B. Johnson, 37th Vice President of the United States,1961[178]

The Great Game for the Space Economy of 2060 is afoot. The United States must seize the moment and this decade's opportunities for US strategic leadership in space. Through a long-term vision, US leadership and strategic partnerships with free and open nations will profoundly benefit life on Earth and establish the necessary norms, values, and rules in space.

History teaches valuable lessons regarding terrestrial economics, finance, markets, supply chains, regulatory policy, government investment, and simplification. The United States must recall all of these lessons if US commercial space and its entrepreneurship are to succeed using national principles of fair and healthy market competition. Commercial space competitiveness requires the United States to adopt a "whole-of-government" approach to align the nation's policies, procurement, investments, tax, and other incentives so that they support early-stage and growing US space companies.

This Report highlights policy gaps and suggests financial tools that must exist for American companies and the US industrial base to mature over the short- and longer-term horizons. Space infrastructure as national strategy and investment requires a portfolio of policymaking and commitments, including: a long-term strategic vision, executive agency for all-space matters, innovation, infrastructure, investors, financiers, commodities, STEM education and training, property rights, global allies, and rule-based markets. Assembling and managing the national portfolio will determine the landscape for creating the space economy of 2060. If the United States wants to be home to the most innovative minds involved in creating and profiting from the Space Economy of 2060, the US policies must commit itself now in the 2020s to adopt policies that get Americans and their dreams there.

Were America's Founders alive to witness how current policymaking is shaping the space economy of 2060, perhaps Alexander Hamilton would advise fashioning a national plan such as below, that:[179]

- augments the US workforce's highly specialized skillsets;
- creates and deploys pioneering technologies;
- grows opportunities for US workers to join in new industries and occupations;
- attracts the best and brightest - the most determined and persevering - of talent;
- actively trains and transitions US workers from every demographic group and circumstance to move them from obsolete and low-paying Industrial Age jobs to jobs that unleash their energies and enthusiasm;
- encourages new business models to develop in the hands of talented entrepreneurs by sharing an appropriate proportion of the scientific, financial and other risks of their activities in space; and
- builds national security by growing the portion of the ownership of and wealth from, the space economy among US companies, investors and individuals.

ENDNOTES

[177] "Text of President John F. Kennedy's Moon Speech at Rice University." Ricetalk. 12 September 1962. https://er.jsc.nasa.gov/seh/ricetalk.htm

[178] Lyndon B. Johnson, Vice President, Memorandum for the President, "Evaluation of Space Program," 28 April 1961, NASA Historical Reference Collection, NASA Headquarters, Washington, D.C. https://history.nasa.gov/Apollomon/apollo2.pdf

[179] Adapted from the seven principles described in Alexander Hamilton, Final Version of the Report on the Subject of Manufactures (Original Reports of the Secretary of the Treasury, 1791–1792 - December 5, 1791), https://founders.archives.gov/documents/Hamilton/01-10-02-0001-0007#ARHN-01-10-02-0001-0007-fn-0123

APPENDIX A

Federal Incentives for the Energy Industry over 50 years: 1953 - 2003

($BN of 2020 dollars - Adjusted 2003 estimates for inflation @ $1 in 2003 = $1.42 in 2020)[180]

Federal Incentives	Oil	Coal	Natural Gas	Hydro	Nuclear	Renew-ables	Geo-thermal	Total	Percent
Taxation	$220.67	$37.91	$107.35	$14.91	$0.00	$16.61	$1.99	$399.45	43.66%
Regulation	$150.66	$8.80	$4.12	$5.82	$14.06	$0.00	$0.00	$183.46	20.05%
Research and development	$9.51	$38.77	$7.95	$1.70	$86.05	$23.29	$4.12	$171.39	18.73%
Market activity	$6.39	$2.41	$2.41	$76.82	$0.00	$1.85	$1.99	$91.87	10.04%
Government services	$38.62	$17.89	$1.85	$1.85	$1.70	$2.41	$0.00	$64.33	7.03%
Disbursements	$2.98	$9.09	$0.00	$1.99	-$11.79	$2.13	$0.00	$4.40	0.48%
Total Federal Incentives 1953 - 2003	**$428.84**	**$114.88**	**$123.68**	**$103.09**	**$90.03**	**$46.29**	**$8.09**	**$914.91**	**100.00%**
Percent of Federal Incentives 1953 - 2003	46.87%	12.56%	13.52%	11.27%	9.84%	5.06%	0.88%	100.00%	
Share of 2003 US Energy Supplied (Quadrillion BTUs)	11.96	22.09	21.93	2.79	7.96	2.98	0.17	69.88	
Percentage of 2003 US Energy Supplied	17.11%	31.61%	31.38%	4.00%	11.39%	4.26%	0.25%	100.00%	

Federal Incentives for the Energy Industry over 66 years: 1950 - 2016

($BN of 2020 dollars - Adjusted 2015 estimates for inflation @ $1 in 2015 = $1.09 in 2020)

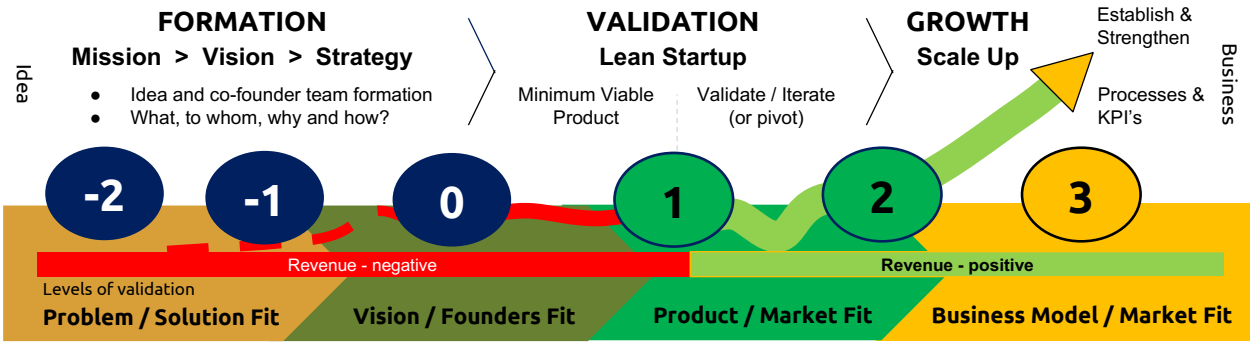
Federal Incentives	Oil	Renew-ables	Natural Gas	Coal	Hydro	Nuclear	Geo-thermal	Total	Share
Tax Policy	$237.62	$91.56	$132.98	$43.60	$15.26	$0.00	$2.18	$522.11	57.07%
Regulation	$195.96	$1.42	$7.10	$15.62	$8.52	$25.56	$0.00	$254.18	27.78%
R&D	$12.78	$45.44	$11.36	$61.06	$2.84	$120.70	$8.52	$262.70	28.71%
Market Activity	$11.36	$5.68	$4.26	$4.26	$110.76	$0.00	$2.84	$139.16	15.21%
Government Services	$53.96	$4.26	$2.84	$26.98	$2.84	$2.84	$0.00	$93.72	10.24%
Disbursements	$4.26	$48.28	$0.00	-$5.68	$4.26	-$38.34	$1.42	$14.20	1.55%
Total Federal Incentives 1950 - 2016	**$587.88**	**$224.36**	**$198.80**	**$159.04**	**$149.10**	**$110.76**	**$15.62**	**$1,445.56**	**100.00%**
Percent of Federal Incentives 1950 - 2016	64.26%	24.52%	21.73%	17.38%	16.30%	12.11%	1.71%	100.00%	
Share of 2016 US Energy Supplied (Quadrillion BTUs)	18.51	7.74	32.24	14.67	2.47	8.43	0.21	84.27	
Percentage of 2016 US Energy Supplied	21.97 %	9.19 %	17.41%	38.26 %	2.93%	10.00%	0.25%	100.00 %	

ENDNOTES

[180] Sources for Appendix A appear at footnote 92

APPENDIX B

Lifecycle Stages of Startup Companies – Entrepreneur's Perspective[181]



Ideating

Entrepreneurial ambition and/or potential scalable product or service idea for a big enough target market. Initial idea on how it would create value. One person or a vague team; no confirmed commitment or no right balance of skills in the team structure yet.

Concepting

Defining mission and vision with initial strategy and key milestones for next few years on how to get there. Two or three entrepreneurial core co-founders with complementary skills and ownership plan. Maybe additional team members for specific roles also with ownership.

Committing

Committed, skills balanced co-founding team with shared vision, values and attitude. Able to develop the initial product or service version, with committed resources, or already have initial product or service in place. Co-founders shareholder agreement (SHA) signed, including milestones, with shareholders time & money commitments, for next three years with proper vesting terms.

Validating

Iterating and testing assumptions for validated solution to demonstrate initial user growth and/or revenue. Initial Key Performance Indicators (KPI's) identified. Can start to attract additional resources (money or work equity) via investments or loans for equity, interest or revenue share from future revenues.

Scaling

Focus on KPI based measurable growth in users, customers and revenues and/or market traction & market share in a big or fast growing target market. Can and want to grow fast. Consider or have attracted significant funding or would be able to do so if wanted. Hiring, improving quality and implementing processes

Establishing

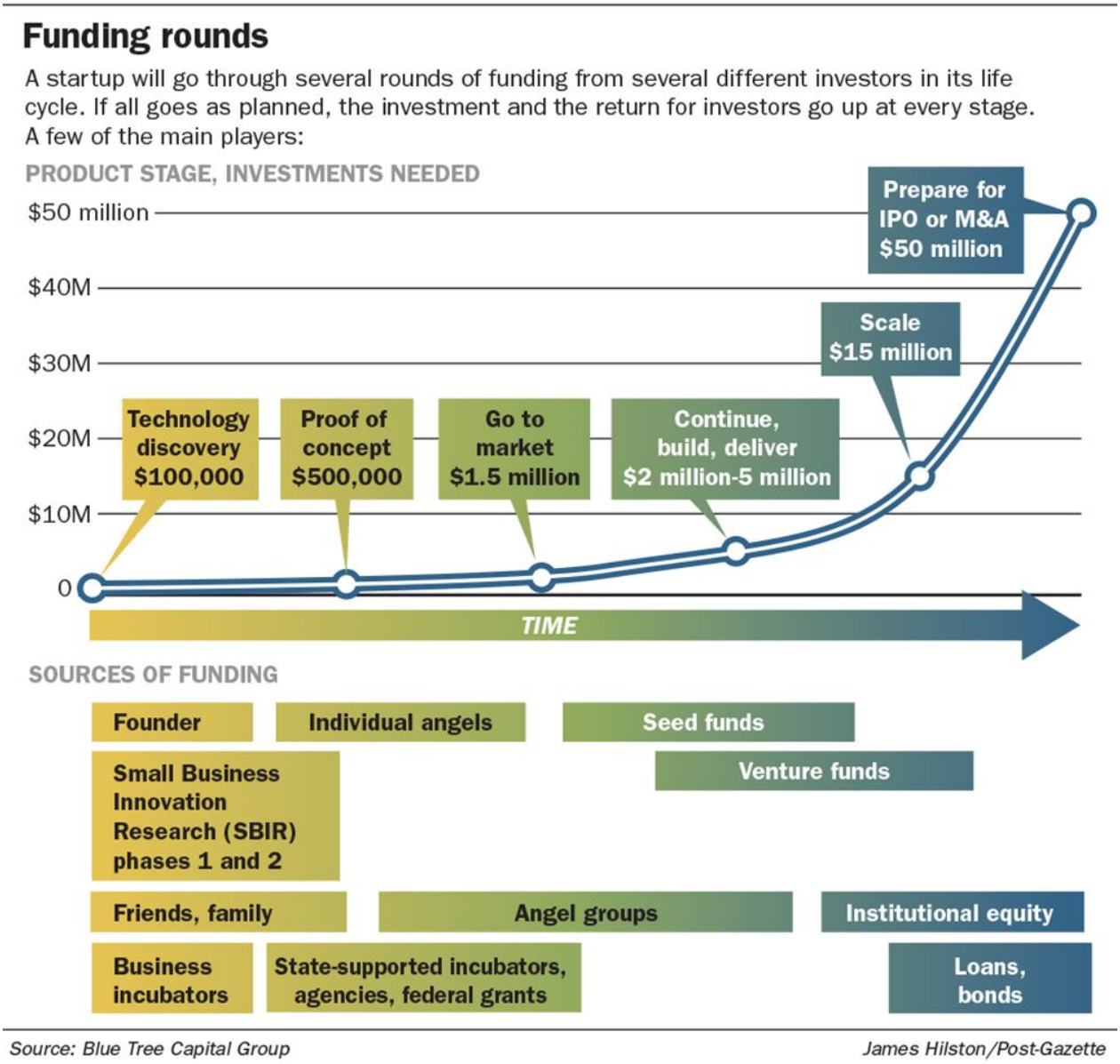
Achieved great growth, that can be expected to continue. Easily attract financial and people resources. Depending on vision, mission and commitments, will continue to grow and often tries to culturally continue "like a startup". Founders and/or investors make exit(s) or continue with the company.

Talent — Organization

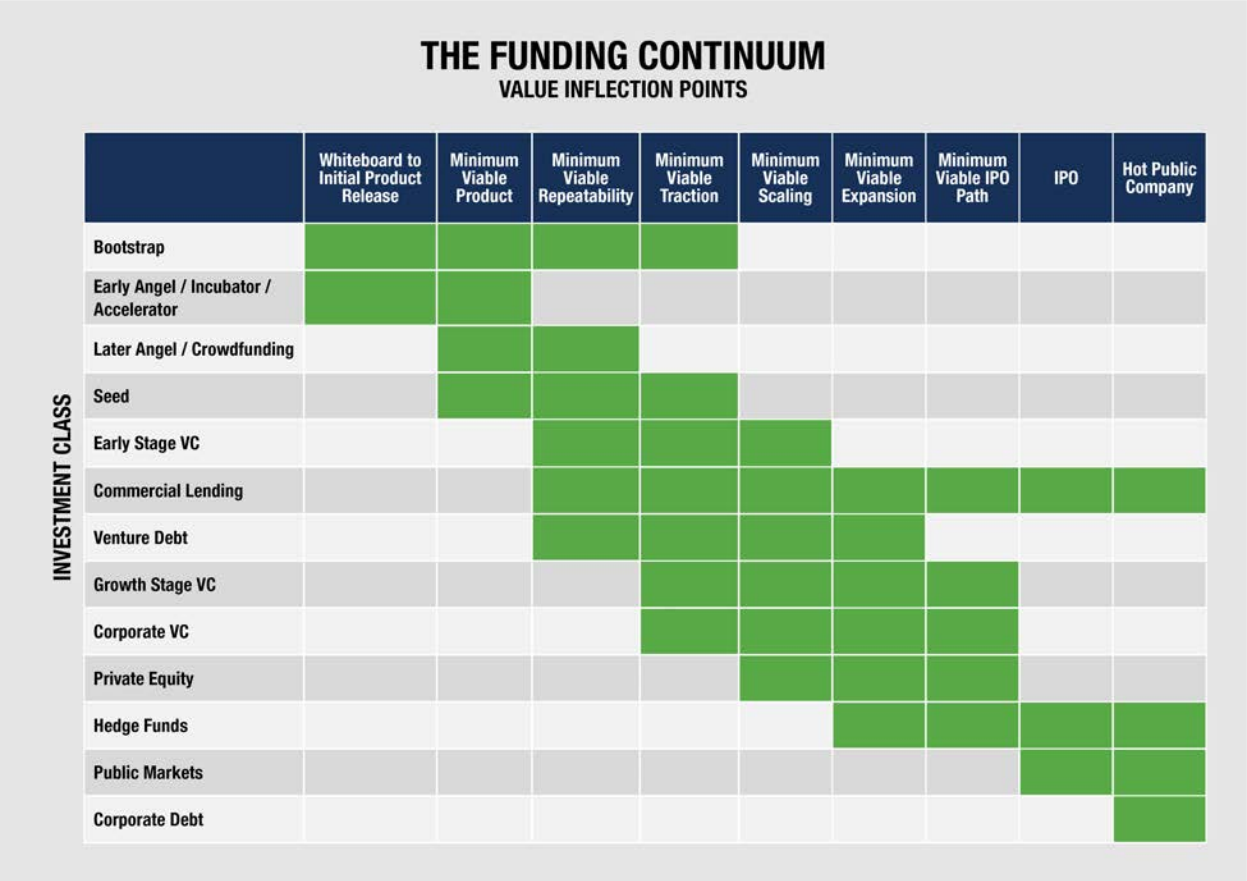
Startup Development Phases - *from **idea to business** and **talent to organization**.*

Version 3.6 - www.startupcommons.org

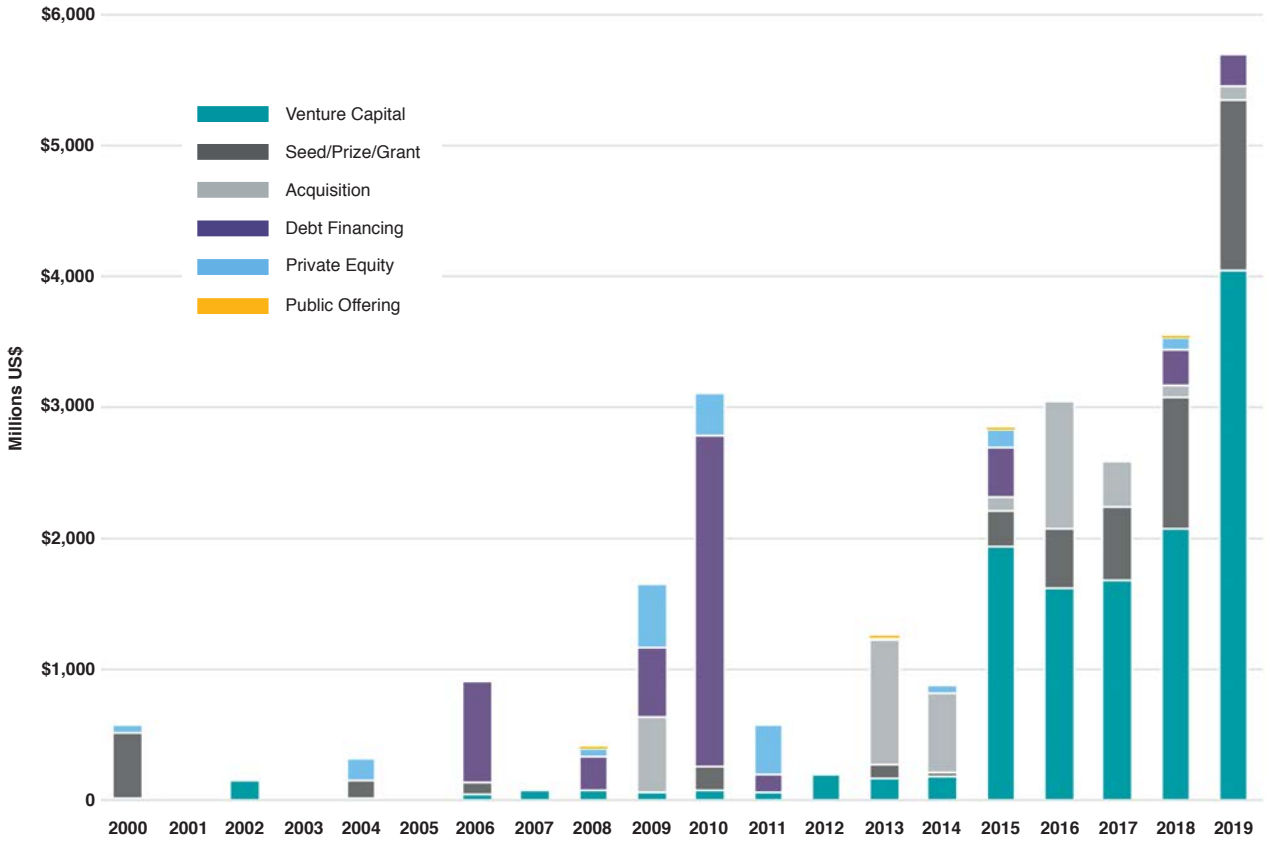
Lifecycle Stages of Startup Companies – Angel Investors' Perspective[182]



Lifecycle Stages of Startup Companies – Continuum of Investors' Perspective[183]



Mix of Capital Invested in US Commercial Space 2000 - 2019[184]



ENDNOTES

[181] Adapted from Startup Commons, *Startup Development Phases – Version 3.6*, https://www.startupcommons.org/startup-development-phases.html

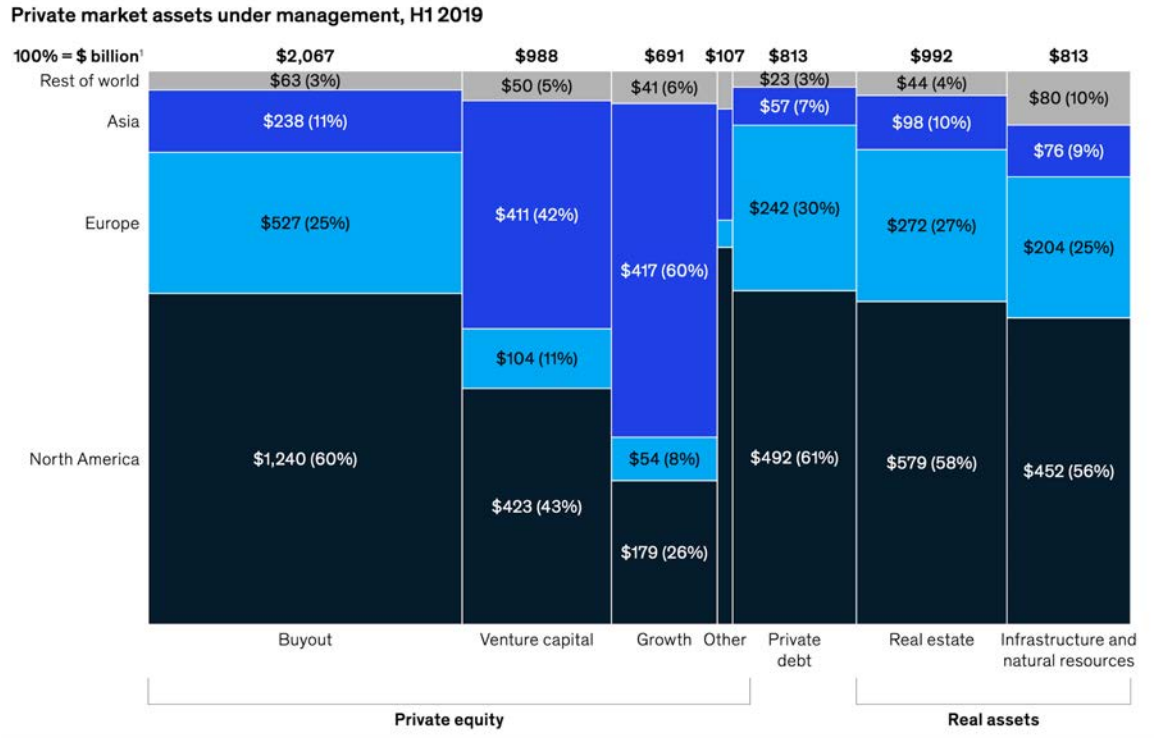
[182] Lauren Rosenblatt, *Angel investors are the first to take a risk — or turn people away — in funding for hopeful startups* (Pittsburgh Post-Gazette – January 13, 2020), https://www.post-gazette.com/business/bop/2020/01/05/Blue-Tree-Capital-Group-angel-investors-venture-capital-tech-startups/stories/202001050001

[183] Tom Mohr, *Funding & Exits: Chapter 3, the Investor Continuum* (August 28, 2018), https://medium.com/ceoquest/funding-exits-chapter-3-the-investor-continuum-3585656afd9f

[184] Bryce Space and Technology, *Start-Up Space: 2020 Update on Investment in Commercial Space Ventures*, https://brycetech.com/reports/report-documents/Bryce_Start_Up_Space_2020.pdf.

APPENDIX C

Private Market Assets Under Management (AUM) H1 2019[185]

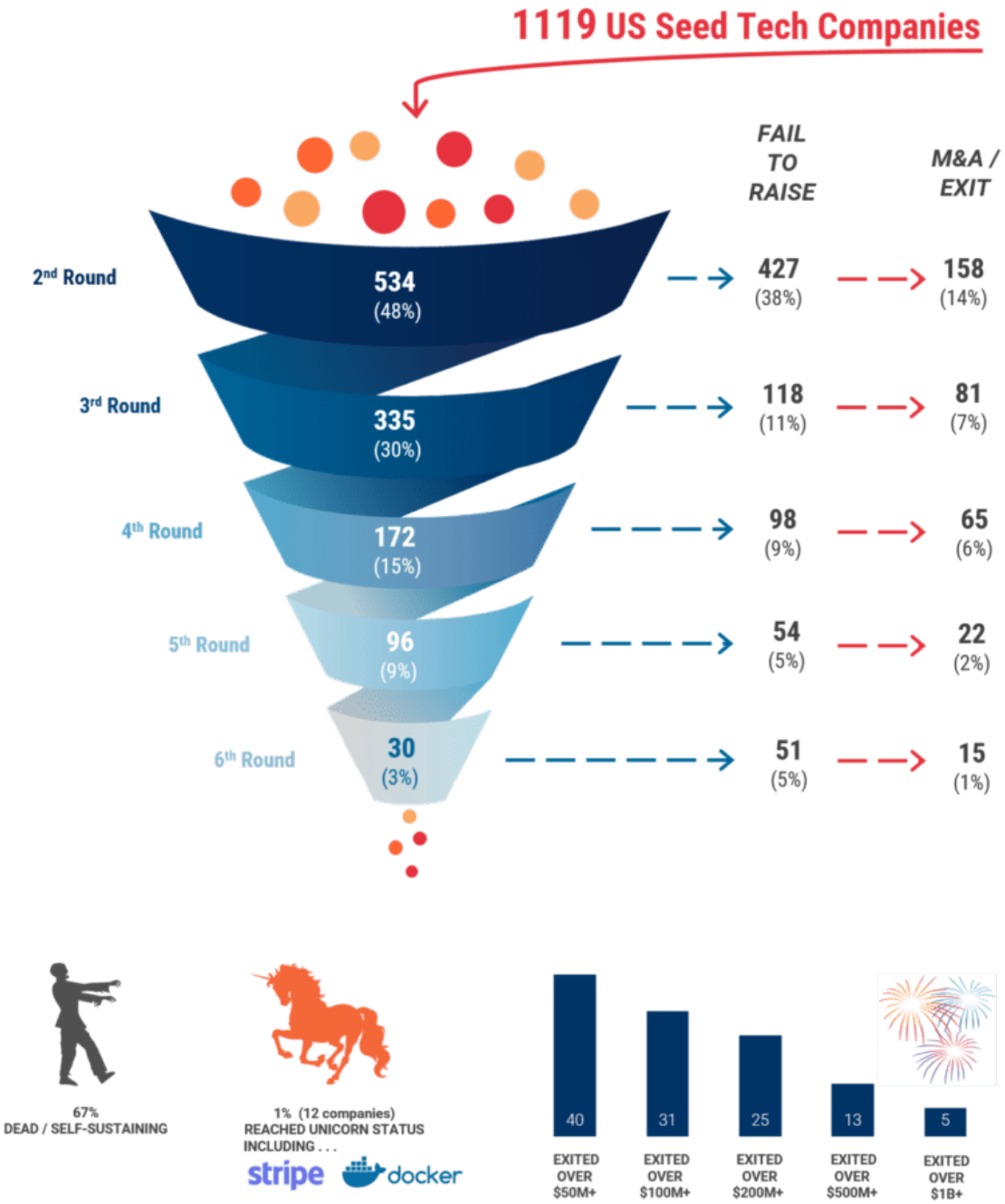


ENDNOTES

[185] McKinsey & Company, *A new decade for private markets: McKinsey Global Private Markets Review 2020* (February 2020), https://www.mckinsey.com/~/media/mckinsey/industries/private%20equity%20and%20principal%20investors/our%20insights/mckinseys%20private%20markets%20annual%20review/mckinsey-global-private-markets-review-2020-v4.ashx.

APPENDIX D

Venture Capital Funnel that Winnows Fraction of Highly Valuable Startups[186]



ENDNOTES

[186] CB Insights, *Venture Capital Funnel Shows Odds Of Becoming A Unicorn Are About 1%* (September 6, 2018), https://www.cbinsights.com/research/venture-capital-funnel-2/

APPENDIX E

Sources of Venture Capital: Foreign and Domestic Shares 2007 - 2019

US as a % of Global VC Deal Flow by Year[187]

Year	Global Deal Value ($B)	US Deal Value ($B)	Global Deal Value (#)	US Deal Value (#)	US as % of Global ($)	US as % of Global (#)
2007	$47.6	$37.9	6,499	4,338	**79.6%**	**66.7%**
2008	$49.8	$36.9	7,218	4,772	**74.0%**	**66.1%**
2009	$37.0	$27.5	6,988	4,546	**74.2%**	**65.1%**
2010	$47.2	$31.6	8,943	5,463	**66.9%**	**61.1%**
2011	$66.0	$44.8	11,381	6,822	**67.9%**	**59.9%**
2012	$62.0	$41.3	13,604	7,958	**66.6%**	**58.5%**
2013	$71.4	$47.7	16,785	9,413	**66.8%**	**56.1%**
2014	$114.8	$72.3	20,212	10,720	**62.9%**	**53.0%**
2015	$158.1	$83.5	22,481	11,073	**52.8%**	**49.3%**
2016	$161.8	$78.1	21,286	9,694	**48.3%**	**45.5%**
2017	$183.9	$87.1	21,952	10,392	**47.4%**	**47.3%**
2018	$308.5	$141.8	23,726	10,648	**46.0%**	**44.9%**
2019	$257.3	$133.4	23,268	11,359	**51.9%**	**48.8%**

ENDNOTES

[187] National Venture Capital Association, *NVCA 2020 Yearbook*, https://nvca.org/wp-content/uploads/2020/03/NVCA-2020-Yearbook.pdf

APPENDIX F

Registrants for the Space Policy and Finance Working Group

Scott	Suhr	Aerospace Corporation
Eric	Felt	AFRL Space Vehicles Directorate
Thomas	Cooley	AFRL Space Vehicles Directorate
Peter	Garretson	AFRL/RV
Jose	Ocasio-Christian	Caelus Partners
Micah	Walter-Range	Caelus Partners
Steve	Butow	Defense Innovation Unit
Katherine	Koleski	Defense Innovation Unit
Pav	Singh	Defense Innovation Unit
Mir	Sadat	Department of Defense
Joseph	Pauloski	Department of Treasury
Jason	Aspiotis	Finsophy PBC
Bhavya	Lal	IDA Science & Tech. Policy Inst.
Daniel	Ceperley	LeoLabs
Michael	Laine	LiftPort Group
Hoyt	Davidson	Near Earth LLC
Brad	Blair	NewSpace Analytics LLC
Casey	DeRaad	NewSpace New Mexico
Karl	Dahlhauser	OUSD R&E
Jeff	Thoben	Quilty Analytics
Steve	Nixon	SmallSat Alliance
Frank	Turner	Space Development Agency
Meagan	Crawford	Space Fund
Bruce	Cahan	Stanford University / Urban Logic, Inc.
Timothy	Cox	Tiger Innovations
David	Shogren	Treasury Department/CFIUS
Scott	Maethner	Universal Technology Company
Stephen	Melvin	US Navy
Alan	Brechbill	US Space Force ‘
Timothy	Locke	US Space Force / SAF/AQRT
Albert	Varma	US Space Force HQ/ST
Jeff	Rich	Xplore Inc.

APPENDIX G

Acronyms, Abbreviations And Conceptual References

To help readers navigate the lexicon of relevant concepts and touchpoints, this Report references the following frequently used acronyms, abbreviations, and concepts:

Acronym	Definition
AFRL	Air Force Research Lab [DoD]
AI	Artificial Intelligence
CCL	Commerce Control List [DOoC]
CFIUS	The Committee on Foreign Investment in the United States
CFTC	Commodity Futures Trading Commission
Congress	U.S. Senate and U.S. House of Representatives
COVID-19	Coronavirus Disease 2019 Pandemic
DAF	U.S. Department of Air Force [DoD]
DFC	U.S. International Development Finance Corporation
DHS	U.S. Department of Homeland Security
DIU	Defense Innovation Unit [DoD]
DoC	U.S. Department of Commerce
DoD	U.S. Department of Defense
DOEd	U.S. Department of Education
DoJ	U.S. Department of Justice
DoS	U.S. Department of State
DoT	U.S. Department of Transportation
DPC	Domestic Policy Council [EOP]
DSS	Defense Space Strategy [DoD]
EOP	Executive Office of the President
EXIM	Export-Import Bank of the United States
FAA	Federal Aviation Administration [DoT]
FATF	Financial Activities Task Force
FBI	Federal Bureau of Investigation [DoJ]
Five-Eyes	Intelligence Alliance among Australia, Canada, New Zealand, the United Kingdom, and the United States.

Acronym	Definition
FFRDC	Federally Funded Research and Development Center
FHA	Federal Housing Administration
GDP	Gross Domestic Product
GPS	Global Positioning System
GSE	Government-Sponsored Enterprise
IC	Intelligence Community
IP	Intellectual Property
IPO	Initial Public Offering
INTERPOL	International Criminal Police Organization
LEO	Low Earth Orbit
M&A	Merger & Acquisition
ML	Machine Learning
NASA	National Aeronautics and Space Agency
NEC	National Economic Council [EOP]
NOAA	National Oceanic and Atmospheric Agency [DoC]
NSC	U.S. National Security Council [EOP]
NSF	National Science Foundation
NSpC	U.S. National Space Council [EOP]
NSNM	NewSpace New Mexico
OBOR	One Belt And One Road Initiative [China]
ODNI	Office of the Director of National Intelligence
OMB	Office of Management and Budget [EOP]
OPR	Office of Primary Responsibility
OSTP	Office of Science and Technology Policy [EOP]
OTMP	Office of Trade and Manufacturing Policy [EOP]
R&D	Research and Development
SBA	Small Business Administration
SBIR	Small Business Innovative Research
SIB	Space Industrial Base
State	U.S. Department of State
S&T	Science and Technology

Acronym	Definition
STEM	Science, Technology, Engineering, and Mathematics
TAM	Total Addressable Market
Treasury	U.S. Department of the Treasury
US	United States
USML	U.S. Munitions List [DoS]
USAF	U.S. Air Force [DoD]
USSF	U.S. Space Force [DoD]
USSPACECOM	U.S. Space Command [DoD]
VC	Venture Capital

INDEX OF KEY TERMS