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FINAL REPORT

Optimizing the Financing of Innovation to Accelerate National Security Capabilities

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Financing for Innovation 2022

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Finance Industry Study Overview and Abstract

On June 20, 1790, James Madison, Alexander Hamilton, and Thomas Jefferson established the financial groundwork for the United States of America (U.S.) over dinner.[1] Their agreement led George Washington's Administration to the following: assume the states' debt; restructure wartime debt; build strong federal tax capacity; lay the foundation of public credit; create a national bank, and promote the development of financial markets.[2] That dinner meeting laid the cornerstones of the financial system that is the backbone of American industry and innovation. Today, the United States has the world's largest equity markets and premier banking sector (measured by assets). The U.S. dollar is the world's reserve currency due to the depth and liquidity of U.S. financial markets, the size and openness of the U.S. economy, and the international trust in U.S. institutions and the rule of law, allowing the U.S. to influence global monetary system standards.[3]

The March 2021 interim National Security Strategy and the 2018 National Defense Strategy (NDS) state clearly that investing in innovative technologies and products is key to our national security and economic prosperity.[4] Recognizing the connection between the financial instruments of U.S. national power, the Financing for Innovation Industry Study (hereafter referred to as the Industry Study) undertook a five-month effort to: understand the U.S. financial industry; elucidate financing of the U.S. defense innovation ecosystem; analyze incentives from investor and investee perspectives; provide policy recommendations to more effectively and efficiently promote investment in defense innovation.

The Industry Study engaged 75 domestic and international stakeholders. These included angel investors, venture capital firms, investment banks, commercial banks, government policymakers, regulators, lobbyists, innovation incubators and facilitators, and academics and think tank representatives in Washington, DC, New York, NY, and Boston, MA in addition to virtual meetings. Research and discussion focused on the U.S. financial system, regulatory compliance, sanctions, financing options, financial technology (fintech), digital assets and currencies and other disruptive technologies, government subsidies, regional ecosystems including state and local support, U.S. Department of Defense (DoD) innovation institutes, and comparative analysis with Europe, China, and Russia. As a result of classroom studies and external engagements, the Industry Study concluded that risk capital has the most significant bearing on the defense innovation network.

The following analysis focuses on the role of the DoD in funding innovation and how the DoD can and should leverage risk capital. The 2018 NDS supports the adoption of cutting-edge technologies like artificial intelligence (AI), cybersecurity, machine learning, and autonomy. But the DoD is not fully leveraging the power of the U.S. financial system to maximize its investments in these critical technologies. The Industry Study's recommendations will allow the DoD to more effectively finance innovation using the existing advantages of the U.S. financial industry.

Table of Contents

I. Executive Summary

The U.S. finance industry is robust and well-resourced, offering a range of commercial and consumer banking, lending, and investment services to individuals and institutions across the country and the globe. Innovation within the finance industry is usually financed by risk capital firms seeking innovation with the potential for commercial success and high returns on investment. Financing innovation is considered a high-risk endeavor due to high startup failure rates, unproven technology, and the challenges of scaling to market production. Finding and applying innovation funding for potential defense market products is even more difficult, given the single buyer in the form of the DoD, the consolidated nature of the private defense industry, and the draw of higher, faster returns in the commercial sector. These factors limit private investment in national security-oriented start-ups. They also resulted in a divergence between the high technology capabilities in the commercial marketplace and the outmoded technology often found within the DoD and the broader U.S. Government (USG). To correct this imbalance, the DoD must take the following actions: increase and expand the investment tools within the innovation ecosystem, scale innovation ecosystem products to operations, and support America's continued innovation advantage to be more relevant, complementary, and agile.

The Industry Study suggests that for the U.S. to prevail over China in a race for the primacy of national defense systems, the DoD must adopt processes that broadly leverage the strength of the many U.S. innovation ecosystems, better scale DoD acquisitions while optimizing inclusion of the private finance industry to rapidly bring forward disruptive technologies, and expand both the quality of human capital and the ubiquity of financial technology advancements that are foundational across the finance industry, the commercial marketplace, and the DoD. To better leverage disruptive innovation and financial structures, the DoD should: 1. Recalibrate the

DoD Innovation Network, 2. Bridge the Procurement Valley of Death, and 3. Maintain Innovation Advantage Through Financing and Human Talent. The DoD culture that evolves from these changes will be better postured to incorporate financing focused on transforming ideas into capabilities *relevant* in future warfare, *complementary* to the private industry's technological trends, and *agile* in converting loosened requirements into capabilities increasingly consumable as technology advances. As the DoD's innovation ecosystem is at an inflection point in history, its ability to finance innovation is too. This paper will present the Industry Study's findings on the strategic environment for financing innovation related to national security, identify the key stakeholders and interests, review the range of financing sources known in the industry as the capital stack *(see Appendix B for Glossary)*, identify challenges specific to defense innovation, and conclude with policy recommendations to make innovation financing more *relevant, complementary*, and *agile* to support national security objectives.

II. The Strategic Environment of National Security Financing

China's impressive rise to economic parity with the U.S. rapidly increases the stakes of strategic competition. In the last quarter-century, U.S. gross domestic product (GDP) nearly doubled, while China's GDP grew by a factor of twenty.[5] While China's economy rapidly expands, the DoD is facing the prospect of flat or declining budgets consumed mainly by personnel costs and major systems acquisitions and sustainment. The 2018 U.S. NDS directly identified China as America's pacing threat.[6] Meanwhile, Russia invaded Ukraine in 2022 and deliberately defied the rule of law, increasing the potential for significant conflict on two fronts.[7] This geopolitical competition gives urgency to DoD efforts to evolve its acquisitions and innovation systems to better leverage relevant commercial technologies to enhance warfighting capabilities.[8] Today's challenges require a repeatable process for financing novel ideas and engaging new generations of engineers and entrepreneurs to strengthen national security.

Private sector and government innovation have long underpinned U.S. economic advancement and are fundamental to national defense. A sound financial sector shaped by free-market principles, prosperity, and equitable USG regulation has fueled U.S. economic advancement and security.[9] The U.S. financial sector is arguably still the healthiest and wealthiest globally, with abundant private capital to finance commercial innovation.[10] Today, the U.S. financial sector is in a strong position. Still, the financial industry is facing revolutionary operational shifts with the rise of fintech. The extensive regulatory environment imposes costs on the financial sector. These costs and requirements also create barriers to entry that have reduced competition and advantage large financial firms. The rise of cryptocurrencies and blockchain-enabled value-transfer services could significantly disrupt traditional financial markets and financial industry leaders. Advances in robotics, AI, and quantum computing could have similar effects.[11]

USG spending once accounted for most U.S. research and development (R&D) spending, with national security as the focal point. This balance began to shift during the Cold War as commercial R&D spending overtook USG R&D investments (*see Appendix A, Figure 2*).[12] Dramatic increases in commercial R&D offset declining USG R&D expenditures. However, private investors have also shifted the focus of U.S. R&D. Privately funded R&D is focused on developing products for a market that will reap significant economic profits. Commercial technology promises larger markets and quicker returns, making it more attractive to private investors (*see Appendix A, Figures 1-3*).[13] As a result, furthering national security objectives is no longer a primary objective for most U.S. R&D investments. While these two aims can align, DoD's ability to influence innovation efforts is waning, requiring greater collaborative engagement with innovators and the financial sector.[14]

Further complicating DoD optimization of U.S. R&D efforts is the rise of risk capital-funded R&D. Funding from U.S.-based venture capital (VC), venture deby (VD), investment banks, and angel investors have grown ten-fold over the past three decades.[15] However, firms funding start-ups require larger exits or buyouts to achieve return-on-investment (ROI) objectives on these high-risk investments *(see Appendix A, Figures 4 & 5*).[16] VC investment in the U.S. doubled from $167 billion in 2020 to $329 billion in 2021.[17] Most VC capital is invested in small, innovative firms identified as having significant growth potential. Because VC investors are seeking the next "unicorn"—a company with the potential to reach valuations of $1 billion or more.[18] The rapid growth required to develop unicorns does not align well with the defense sector, making national security investments less attractive for VC investors.[19]

In the U.S., seeding and growing business is primarily a private-sector function. However, the USG might play an advisory role by linking investors and start-ups. Further, declining DoD budgets resulted in the consolidation of primary defense contractors.[20] This history ultimately limits competition and thereby innovation, primarily diverting available funds to the procurement and sustainment of large, long-term, platform-oriented programs (*see Appendix C, Defense Acquisitions and Industrial Base Background*). This budget focus has further disincentivized prime contractors' investment in developing new national security technology products because lucrative long-term sustainment contracts offer a more reliable future profit.[21] In our view, the DoD is not fully leveraging the financial industry and advanced commercial technologies for defense purposes at scale, nor is it launching tools to incentivize finance or commercial technology in the under-resourced sectors.

III. Key Stakeholders and Interests

The key stakeholders in financing for innovation are investors/financiers, start-ups, human capital, Congress, DoD, and industry. These stakeholders are impacted by industry conditions and have differing and sometimes divergent interests in financing innovative technologies. Understanding incentives influencing various finance industry stakeholders can illuminate opportunities for DoD to reduce obstructions to the development and adoption of relevant innovative technologies. A shared interest amongst the key stakeholders is the stability of the U.S. financial market. The U.S. has a complex financial regulatory system with state and federal regulators. At the national level, there are multiple depository regulators, securities markets regulators, and government-sponsored enterprise regulators, and one consumer protection regulator, the Consumer Financial Protection Bureau.[22] While policy debate continues about *how* best to use financial regulation to achieve diverse goals, there is general consensus on the value of market efficiency and integrity, consumer and investor protection, capital formation, taxpayer protection, and prevention of illicit activity, all of which contribute to the financial stability on which the industry depends.[23]

Investors/Financiers

Capital is essential to support any business endeavor and the U.S. has a number of supporting industries and vibrant clusters (*see Appendix D for Financial and Innovation Clusters*). Start-ups go from concept to market research, design, testing, production, and sales with the hope of establishing a recurring revenue stream, requiring capital throughout the process. Most capital for start-ups comes from angel investors and venture capitalists, who pool funds from individuals and institutions to invest for high returns. These investors are seeking returns beyond those they can achieve in public markets and are willing to take more considerable risks with their money to achieve these returns. Some investors are only motivated

by financial returns. Still, others seek investment opportunities in specific sectors they have significant expertise or interest in.

Start-ups

Building a successful firm often takes years of grueling work. Initially, entrepreneurs and start-ups may fund their own efforts or borrow from family or friends. Unfortunately, start-ups cannot turn to traditional commercial lenders when those funds are exhausted because they will not finance such high-risk efforts. Instead, start-ups turn to risk capital, most often VC, which becomes the financial product of choice for start-ups hoping to transition to production and earn recurring revenue. Before committing to work with the DoD, startup firms must carefully assess whether the defense market is right for them. Here, start-ups with a national security focus often turn to commercial opportunities for sustaining revenue because they encounter significant obstacles in entering and succeeding in the defense sector.

Additionally, many companies face substantial challenges bridging prototyping awards with permanent follow-on contracts that provide a steady source of revenue. For example, start-ups can earn $1 million in defense contracts with relative ease, but the next $10 million they need to grow and sustain their business is more difficult.[24] Start-ups also face challenges with scaling because they compete for funding through a bureaucratic acquisitions process that may take two years or more to finalize a long-term contract - time many start-ups cannot afford while meeting investor return requirements.[25] The DoD can be a customer worth pursuing as it may eventually generate recurring revenue, but start-ups must have a business plan that allows for the revenue required.[26]

Human Capital Talent

American innovation relies on people and culture. The financial industry increasingly pursues technology derived from science, technology, engineering, and mathematics (STEM) fields. The U.S. has some of the strongest higher education institutions for the study of science and engineers in the world, but it is no longer the uncontested leader of such education.[27] The U.S. free-market system creates powerful incentives to innovate, ensures that individual earnings reflect the value they deliver and offers upward mobility to those who work hard.[28] U.S. economic policies and the rule of law strongly support business development. In 2021, over 15% of surveyed Americans aged 18-64 were engaged in early-stage entrepreneurship.[29] "Numerous studies have demonstrated that innovation is more likely to occur in societies that reward unconventional thinking."[30] This entrepreneurial spirit is supported by investment in research. According to the 2021 Global Innovation Index, the United States leads in both corporate and academic R&D.[31] Ranking third overall in innovation, the U.S. also ranked highly in total patents and intellectual property returns.[32] With a system that rewards inventors through fair regulations and the rule of law that upholds intellectual property rights, the U.S. incentivizes strong knowledge growth and business development.

Congress

Congress has a vested interest in the strength and surety of the U.S. financial sector, a critical enabler of U.S. and international economic activity, and a cornerstone of U.S. global leadership.[33] The financial industry has strong ties with Congress that serves as an oversight body and advocates for the industry. Lawmakers work closely with industry representatives to identify and address any potential threats to U.S. financial systems. Congress and the Executive

Branch also call on banks to execute U.S. economic policies and actions, including sanctions and anti-money laundering provisions.

Congress also controls the "power of the purse" through the appropriations and authorization processes, which essentially set DoD priorities. In the FY2022 National Defense Authorization Act (NDAA), Congress designated innovation as a priority and called on the DoD to: accelerate the adoption of emerging technologies; advance specific technology categories such as quantum computing, microelectronics, and biotechnology; and streamline collaboration between DoD and extramural researchers.[34] Additional NDAA provisions seek to reform the planning, programming, budgeting and execution process to reduce the constraints that inhibit DoD's ability to respond quickly to technological advances and changing technology requirements.[35]

U.S. DoD

DoD financing plays a vital role in funding innovation because it is non-dilutive capital, which does not require a company to give up equity to the investor. This is especially attractive to firms in the early stages of development and late-stage scaling in the form of government grants and contracts. Defense procurement is unique, placing DoD at the center of one of the largest monopsony markets in the world, awarding over $445 billion in defense contracts in FY20.[36] While the DoD is eager for cutting-edge technologies like AI, machine learning and autonomy, the preponderance of the DoD's budget is allocated to program sustainment.

In financing for innovation, the USG occupies a unique space because its end goal is not to earn financial returns like traditional lenders and investors, but instead to finance technological advances for U.S. economic, social, or national security benefits. While other sources of non-dilutive, non-debt generating capital exist at state and local levels and from non-

profit organizations, these pools are quite small in comparison to federal funds. In FY20, the federal government funded 20% of total U.S. R&D, providing $158 billion in total investments.[37] DoD R&D investments were split with 61% to industry, 30% allocated internally through DoD-led labs and project management, and the remainder to universities and Federally Funded Research and Development Centers (FFRDCs).[38]

Defense Industrial Base

The Defense Industrial Base provides products and services that allow for the sustainment and deployment of military operations including research and manufacturing.[39] While there are more than 100,0000 companies in the U.S. defense industry, the majority of DoD contracts go to just five companies, informally known as the primes.[40] With fewer companies receiving primary contracts, there is less competition and less cause for innovation. Without DoD action, the defense industrial base will continue to consolidate, leaving fewer opportunities to draw in innovative new companies and capabilities, and providing little motivation for risk capital to finance defense-related products.

Defense prime contractors are leveraging the world of Corporate Venture Capital (CVC) to develop defense-related start-ups with commercial value. The five primes have participated in at least 30 rounds of corporate venture funding, investing in drone technology, A.I., space technologies, and electric aircraft.[41] Lockheed Martin Ventures was created in 2007 and has invested over $100 million in the last fifteen years. Lockheed has now committed $200 million to the fund and is focused on AI, autonomy and robotics, cyber, materials and manufacturing, quantum, sensors, space, and other emerging technologies.[42]

IV. Capital Stack for Financing Innovation

Financial capital is the lifeblood that enables a company to grow beyond the founder's initial idea (*see Appendix E for Risk Capital and Banks Structure, Conduct, and Performance*). The capital stack refers to the variety of financial products and services that a start-up might leverage to grow the firm. These potential sources of capital include angel investors, VC firms, private equity, corporate investors, banking lenders, and federal funding, all collectively referred to as the capital stack. Most start-ups struggle to endure the initial operating phases before establishing a reliable revenue stream, a period referred to as the start-up valley of death. During this phase, start-ups depend upon angel investors, often family and friends, for initial seed money. As they continue to grow, start-ups require even more funding. However, they are unqualified for business loans and services from commercial banks and traditional lenders without recurring revenue. Start-ups seeking to develop and prove a viable product or service then usually turn to risk capital to fund their ventures.

Angel Investors

Start-ups and entrepreneurs may seek seed money from wealthy individuals known as angel investors, who usually provide between $25,000 - $100,000 in exchange for an equity stake in the business.[43] Angel investors might require a seat on the board of directors and serve as consultants to assist founders based on their expertise and desired involvement.[44] Some angel investors support companies until the founders can secure VC funding.[45]

Venture Capital

VC is essentially investors pooling capital for start-ups and small businesses with long-term growth potential. Investors often seek a return of at least 10 times greater value than their

investment after corporate valuation. Such investors typically take a share of corporate equity and play an active role in corporate management, with an average exit after at least six years.[46] [47]

Private Equity

PE generally refers to an equity investment in exchange for ownership shares in a firm that is not traded publicly.[48] PE funds can be pooled from institutions, firms, or individuals with high net worth. As part of PE, VCs typically invest in early-stage start-ups while the larger investment pool of PE is focused on more established private firms for merger or acquisition potential. PE investors may also evaluate public firms for a potential buyout, i.e., purchasing a mature public company and taking it private.[49]

Corporate Venture Capital

CVCs use investment opportunities to help their parent company garner competitive advantages and new profits. CVCs are either strategically driven or financially driven. Financially driven CVCs invest in new firms for leverage and profits from initial public offerings or sales of the stakes. Strategically driven CVCs invest to increase their sales and profits by making deals with start-ups that use new technologies or are entering new markets.[50] CVCs also serve as a gateway for the possible acquisition of smaller, innovative start-ups. Defense prime contractors like Boeing, Lockheed Martin, and Raytheon have founded their own CVC organizations to capitalize on this growing market. Anello Photonics, part of the Lockheed Martin portfolio, is one example of this dynamic.[51] These defense giants are leaning forward to attract tech start-ups while guiding them through the complicated defense regulatory process.

Venture Debt

VD is a type of loan offered by banks and non-bank lenders explicitly designed for early-stage, high-growth companies with VC backing. Most venture-backed companies raise VD from

specialized banks at some stage, usually because they still require cash but do not want to surrender more equity.[52] All VD follows equity in the capital stack and is not a replacement. Venture lenders use VC funding as a source of validation and the primary litmus test for underwriting a VD loan.[53] In addition to the financing, banks focusing on the innovation economy also provide start-up-centric financial advice, investment and payments solutions, sector insights, and networking assistance to complement investor and board support.[54]

V. DoD Innovation Network and Challenges

Early innovation, funded through basic science R&D, is a bright spot for government financing of innovation. Through its research labs and universities, government-funded basic research often produces the underlying technologies for innovation. However, fiscal pressure reduces federal R&D investments while private sector capital is increasingly preoccupied with more profitable commercial endeavors. This dynamic makes it increasingly difficult to entice the brightest talent to work on government problems. The DoD has created a hedging strategy that continues traditional R&D and weapons system development while developing initial inroads to commercial efforts. To maintain the strategic advantage, DoD must leverage more applied commercial R&D and generate access to innovators, ideas, and technologies with potential military applications.

Reinforcing this point, Massachusetts Institute of Technology (MIT) professors Phil Budden and Fionna Murray write that given the dominance of digital and software companies in R&D spending, the U.S. defense system must go beyond the usual defense contractors to understand the scope and direction of current R&D efforts that shape many of the U.S. innovation ecosystems."[55] Firms rarely spawn revolutionary technologies from evolutionary means, but the DoD still relies on a system of evolution to acquire innovation. Increasing DoD

engagement with privately funded commercial technology innovation ecosystems is the first step.

Over the last five years, defense leaders have awoken to the strategic necessity to spur innovation more directly into defense capabilities rather than hoping the traditional system produces results.[56] As such, the DoD innovation network now consists of 28 discrete organizations designed to engage and harvest technology from innovation ecosystems clustered in areas like the Silicon Valley, Boston, and Austin.[57] These 28 organizations include the Defense Innovation Unit (DIU), SOFWERX, AFWERX, NavalX, and Army Futures Command, designed to bridge DoD's traditional innovation infrastructure (i.e., FFRDCs, University Affiliated Research Centers-UARC, or DARPA) with the private sector and groundbreaking entrepreneurs.[58] In 2020, DoD's innovation network issued an unprecedented number of small contracts, seeding 1,635 firms with more than $1.5 billion in early-stage funding through the Small Business Administration's Small Business Innovation Research (SBIR) program.[59] SBIR is a competitive awards-based program, designed to enable small businesses to explore their technological potential and incentivize commercialization.[60]

Despite some success, the individual DoD innovation network centers lack strategic integration or relative scale, which could allow the DoD to capitalize on promising capabilities while simplifying interfaces between start-ups and the USG.[61] A drought in sizeable contracts for new market entrants mutes the demand signal sent by launching DoD innovation centers, causing angst and apprehension for new defense firms and their investors.[62] Arguably, the DoD is improving engagement through the *WERXs* but struggles to finance technology development to mature a competitive product through scaled production.[63] Therefore, current defense innovation ecosystem stakeholders are beholden to VC and angel investors who push for rapid growth rather

than extended military capability development. This misalignment reveals itself in the contracting valley of death for new capabilities pursuing the promise of an eventual program of record.[64]

The Under Secretary of Defense for Research and Engineering, Heidi Shyu, said in May 2022 that one of her top priorities is addressing these transition challenges by catapulting prototypes into real-world applications.[65] This fundamental shift represents an attempt to refine the DoD's demand conditions to better position companies (small to large) to drive innovation into the defense sector. Ms. Shyu recognized that DOD must give more attention to getting small businesses in the front door, coupled with the bureaucratic knowledge of which door to go through.[66] In addition to the change in approach, Ms. Shyu announced $100 million in acquisition *Valley of Death* funding represented through SBIR Phase II funding for promised firms.[67] This is a positive sign, but DoD innovation centers will struggle to transition programs, let alone integrate them, without a deliberate DoD innovation strategy that capitalizes on bridges between inter-service competitiveness and interoperability. There are still gaps reflected by a lack of SBIR Phase III awards, including transferring technologies in well-funded industrial sectors, advancing less funded sectors, and scaling towards operationalization.

One common solution is for firms with dual-use technology to leverage the benefits of immediate commercial value and potential for long-term defense contracts, which allow them to receive steady revenue from the government to fund disruptive technologies for commercial productization with high potential return on investment. However, many investors shy away from financing firms with USG contracts or those receiving U.S. Small Business Administration's SBIR and Small Business Technology Transfer loans, because the financial lifelines are just temporary revenue streams.[68] Many prominent financiers perceive USG funding

as placing a market chokehold on growth potential, and intentionally steer start-ups away from pursuing partnerships with the DoD.[69] Finally, commercially-oriented firms are seeking fast market growth. Existing DoD acquisition and financing culture runs counter to these agile markets.[70]

Another challenge is that the defense industry traditionally receives direct requests for military platform production with specific requirements. Now the industry is now being asked to adapt existing commercial technology to military needs. DoD cannot defeat its adversaries alone; partnering with industry is critical.[71,72] However, many aspects of DoD acquisition culture favor the existing defense prime contractors, making it challenging to quickly adopt commercial technology.[73] New industry entrants cannot respond quickly to the extensive requirements documents DoD traditionally releases. If DoD can provide high-level, open-ended requirements to industry, rather than prescriptive requirements, new entrants are more likely to propose innovative solutions, building from their expertise in high technology commercial markets. Industry also contends that fixed-price contracts are necessary because they afford greater flexibility to innovate.[74]

While efforts are underway to make it easier to do business with the USG, defense contracting remains cumbersome. Companies providing goods and services to the USG often need separate accounting systems and staff or consultants with security clearances who are also well-versed in intellectual property rights and government contracting requirements. These requirements limit the appeal of working with the government and reinforce contracting relationships with large firms that can benefit from economies of scale and cover higher overhead costs. In addition, the rigid and lengthy federal budgeting and acquisition processes lead to enduring contractual relationships. In other words, the existing process leads to

government contracts that become lucrative because they are often renewed or extended, but they offer no incentive for firms to provide new and innovative solutions for federal purposes.

The lack of substantive change in the industrial base also conveys a scaling issue with the DoD's current efforts. Specifically, in recent decades, the USG's strategy has been to leverage private investment for access to innovation based on its significant rise in the share of overall R&D. Compared to private capital sources, the DoD's strategy provides relatively insignificant funding. For example, any DoD Service or agency that spends more than $100 million annually on R&D must spend 3.2% of their R&D budget on SBIR programs.[75] In spite of this requirement, as captured in Appendix A, Table 1, the Department of the Navy and Air Force only met the minimum SBIR spending requirements 50% of the time between FY16-FY19, while the Department of the Army and OSD never met the minimum requirements. Notably, non-defense federal departments consistently met the minimum 3.2% SBIR requirement. If the DoD had fulfilled the minimum SBIR spending requirements during these years an additional $644 million would have been spent with small businesses on Phase I or II awards. These disparities send a macro-level message to private finance regarding the DoD's support of technology conversion to defense capabilities. Finally, while non-traditional defense firms expect initial awards to result in progressively larger contracts, they also acknowledge scaling and unicorn formulation is extremely rare considering defense industrial base trends.

There is another challenge in the supply of human capital talent to meet requirements to sustain growth in financing for innovation. Specifically, the finance industry is competing for talent with similar skills to those needed in the growing cybersecurity, AI, machine learning, and automation sectors (among others). Further, the National Science Board's July 2021 report on Elementary and Secondary STEM Education shows U.S. student performance on standardized

math and science tests has not improved in over a decade.[76] Compounding the challenge in basic education, the number of foreign students receiving STEM degrees at U.S. institutes of higher education has doubled from 11% in 1988-89 to 22% in 2016-17.[77] This rate is even higher for graduate degrees, as foreign students accounted for 54% of master's degrees and 44% of doctoral degrees in STEM fields in the United States in 2016-17.[78] This data reveals that world-leading U.S. institutes of higher education are training nearly as many foreign students as American students in STEM fields. The existing skill mismatch is predicted to grow even starker as STEM jobs are expected to grow an additional 11% from 2020-to 2030, meaning the DoD Innovation Network will be in an increasingly competitive market for STEM talent.[79]

Financial industry stakeholders understand the challenges inherent in developing a successful bridge between a robust financial industry and the defense-oriented innovation ecosystem. This is true globally as well and is reflected in a comparative analysis of financial industry ecosystems in the U.S., China, and Russia (*see Appendix F for U.S./China/Russia Lines of Effort*). Companies must be allowed to adapt commercial solutions to national security problems. Beyond this, there must be opportunities to scale if the emergence of disruptive innovations into defense competition becomes a reality. The private finance industry has conveyed a willingness to be an additive investor to the DoD's efforts, but only if the system allows success through the entire scaling process. In order to spur successful start-ups, while supporting the broader U.S. financial system and a healthy DOD innovation ecosystem, the USG should recalibrate the DoD innovation ecosystem to better align with private industry, build a bridge across the DOD production valley of death, and maintain U.S. innovation advantage through support for fintech advancements and support for human capital growth.

VI. Policy Recommendations

Innovation Theme #1: Recalibrate the DoD Innovation Ecosystem

Summary: The DoD should optimize innovation finance efforts focused on transitioning dual-use technologies to operational capabilities by committing to innovative small business through expansion of SBIR awards, extending the defense innovation network to include allies, and establishing a loan program office to support hardware development in the U.S. In addition to these recommendations, the Services should support OSD R&E's efforts to create and strengthen a common DoD innovation market among the 28 independent innovation centers. These efforts will optimize the connection of private capital opportunities, accelerate access to commercial R&D, and realign the DoD strategic environment to be *relevant* and *complementary*.

Policy Recommendation #1: Establish a SBIR funding requirement within the DoD and establish the SBIR budget allocation as 4% of R&D. To address the DoD's aforementioned noncompliance with the federal requirement to spend at least 3.2% of the R&D budget on SBIR, an explicit program element code (PEC) will be created that negates funding movement from the SBIR program. Additionally, to increase the scale of this effort in the R&D budget, this PEC would be funded at 4% of total R&D spending, representing an increase of $896 million against the 3.2% federal minimal for a total SBIR funding amount of $4.5 billion.[80]

Policy Recommendation #2: Expand DoD's Innovation Ecosystem to allow participation by the National Technology and Industrial Base (NTIB) military and equivalent small businesses of Canada, the United Kingdom (UK), and Australia.[81] The NTIB was established in the FY93 NDAA to formalize U.S.-Canadian cooperation on defense R&D and dual-use technology development. In FY17, Congress added the UK and Australia to the NTIB.[82] The inclusion of these trusted allies, with their respective industrial bases and financiers, will expand DoD access to new markets and innovative defense technologies. An allied defense innovation ecosystem will increase the scale of the potential defense markets for security-focused companies and make

defense innovation more attractive to potential investors. While including more competitors, the U.S. ecosystem would still benefit by creating multiple early-stage buyers that could expand potential funding for operationalization development and production scaling opportunities.

Policy Recommendation #3: Establish a DoD Loan Program Office (LPO) with a VD program for hardware or emerging technology start-ups and a loan guarantee program for vital defense technologies. This program would offer loans below market rates and be modeled after the Department of Energy's (DOE) loan program office charged with ensuring the resilience of U.S. energy infrastructure. Separately, the DoD loan office should be granted authority to work with banking intermediaries to provide loan guarantees against business projects meant to advance vital defense technologies. These guarantees would apply to a business of any size and be correlated to OSD R&E's critical technology list. The DoD will need to engage with Congress to shift resources and establish the necessary authorities to execute. Additionally, the DoD will need to request limits on required contingent liability holding amounts, like the DOE loan program provisions. Government lending would encourage complementary private investment by signaling long-term interest in the technology and de-risking the significant capital expenditures necessary for hardware or prototype protection and testing.

Risks and Resourcing: Mandating a SBIR R&D funding line would reduce DoD budget flexibility, forcing agencies and services to plan strategic use of SBIR funds. The $4.5 billion commitment would create more robust competition from smaller firms while also incentivizing defense prime R&D. Additionally, mandating the SBIR spending will force greater direct and indirect engagement with VC firms in the capital stack. The NTIB recommendation is resource neutral and depends on a respective NTIB country's desire to participate. Establishing an international innovation ecosystem requires a foundation of trust and the Industry Study

recognizes that relationships ebb and flow with domestic political shifts and reactions to globalization.[83] Security concerns could emerge in international R&D efforts but restricting these partnerships to long-standing allies reduces this risk. Regarding the DoD LPO, the financing in the initial year would be 1.5% of the R&D budget, or $1.68 billion. A first tranche would cover the initial loans and require a contingent liability in subsequent years of 30%. If the contingent liability is not used, funds could be rolled forward to cover future loans as initial loans are paid off. The remaining funding would be held at a 5% loan failure rate to support loan guarantee authority through banking intermediaries.

This innovation theme would be funding neutral, with the potential to generate revenue if the DoD LPO can emulate the DOE's loan program success. The DOE loan program office has generated over $3 billion in revenue since 2009 by offering interest rates below market level.[84] The budget realignment to spend 4% of DoD R&D funding on SBIR and 1.5% for the DoD LPO would be sourced from the DoD budget as a reduction in experimental and operational R&D funding, which predominantly goes to defense prime contractors. These recommendations would not adjust the R&D funding levels for the FFRDCs, UARCs, Service Labs, and DARPA.

Innovation Theme #2: Building a Bridge Across the Valley of Death

Summary: The DoD needs to adjust the traditional acquisition system to facilitate new entrants into the production phase and beyond. The failure of the DoD acquisition system to support product scaling beyond the R&D phase is a missed opportunity to engage the later stage of PE financing, and risks eliminating the limited VC financing that has been established in the last five years. Private financing is vital as it is additive to the capability gains being directly funded by the DoD. This will better address the *relevance* and *agility* of DoD innovation financing within the strategic environment.

Policy Recommendation #1: Establish a Small Business Innovation Production (SBIP) Fund at 1% of the DoD procurement budget dedicated to SBIR Phase III procurements. This reallocation would create a $1.3 billion fund based on FY22 budget figures.[85] A DoD SBIP Fund would bridge the costly late-stage production valley of death, ensuring more emerging technology reaches the hands of the warfighter. Government capital investment could also spark complementary investments from VCs that typically avoid defense-related investments without a strong government demand signal and assurance of follow-on contracts.

Policy Recommendation #2: To realign demand, requirement documents (and subsequent funding programs) should be more capability-based and portfolio managed. Services should also align the creation of integrated priority lists, which establish procurement requirements, with their respective SBIP engagement to maximize potential SBIP participation. Further, project managers should conduct due diligence of commercial markets, akin to that conducted by VC firms, before finalizing requirements. Increased competition will increase the capacity for more creative solutions and potential for greater returns to new companies.

Policy Recommendation #3: Incentivize primes and other U.S. contractors to subcontract with DoD-funded manufacturing advancement initiatives and SBIP awardees. National Institute of Standards and Technology Manufacturing Extension Partnership and Manufacturing USA participants represent a source of DoD funding to advance manufacturing innovation in the commercial and defense markets.[86] Both the nonprofit companies that comprise these DoD-funded manufacturing initiatives and SBIP small businesses represent advancements in U.S. manufacturing capability. This would create an optional incentive for acquisition professionals to leverage during competitions in order to encourage prime contractors to engage and subcontract with these existing DoD manufacturing initiatives and partners

Risk and Resourcing: This is resource neutral as it transfers existing funds within the DoD budget. The initiative to modify requirements would require balancing congressional oversight and schedule increases while assuming additional acquisition risk by incorporating personnel trained in business initiatives into the requirement development process. This could be managed with redistribution of centralized joint requirements personnel and distributed acquisition command support staff. Incentivizing primes to sub-contract those receiving funding through DoD manufacturing initiatives would be resource neutral and preserve a prime's independence in selecting subcontractors. Incentives would complicate source selections and require additional manhours to manage contractor adherence to the established subcontracting goals.

Innovation Theme #3: Maintain Innovation Advantage Through Financing and Human Talent

Summary: The U.S. has a decisive advantage over adversaries in financing innovation and a limited advantage in providing the elite human talent necessary for its continued advancement, but it could lose that preeminence if it does not generate sufficient talent to meet future requirements. USG policies can be optimized to maximize and expand existing human talent to remain *relevant*, encourage further investment of top talent in the DoD Innovation Network to be *complementary* to private industry, and ultimately generate greater and more *agile* outputs that strengthen national security objectives.

Policy Recommendation #1: Expand programs to encourage STEM studies across basic and higher education. Specifically consider the STEM Education Coalition's 2021 recommendations calling for bipartisan, broad-based support for STEM education with full interagency participation.[87] Specific recommendations include full STEM education funding for states and districts under the 2015 Every Student Succeeds Act (ESSA), which requires that states assess science skills as well as reading and math, increased funding for Supportive Effective Instruction

Grants to expand educational training for STEM educators, and higher education policies that support emerging pathways into STEM careers beyond the traditional 4-year university experience to expand the STEM talent pipeline.[88] The USG should further consider local and state-level public-private partnerships with private sector-led STEM programs such as the Intel Corporation's She Will Connect, which provides introductory engineering programs to middle school girls, or the JPMorgan Chase and Company Schools Challenge, which provides mentoring through STEM skills challenges for 12 – 15-year-old children.[89]

Policy Recommendation #2: Create a new visa category for startup entrepreneurs, establishing two-year residency permits with an annual renewal option and flexible options for residency and immigration for scientists and researchers who were PhD students in the United States. This would create an option for foreign-born higher education STEM students to extend their contribution to the U.S. economy beyond their university fees and address the gap in the U.S. talent pipeline. According to MIT research, per capita, immigrants are about 80% more likely to found a firm than U.S.-born citizens. On average, those firms also have about 1% more employees than those founded by U.S. natives.[90]

Policy Recommendation #3: Support the advancement of financial technologies. The USG should support ongoing efforts to enable the U.S. financial industry to remain a global leader. A March 2022 executive order directs responsible development of digital assets.[91] The wide range of policies surrounding the financial industry, including banking regulations, taxes, investment criteria, and rulings on individual financial actions, all support the agility of the financial industry and allow it to remain competitive both globally and domestically. Such policies should continue to favor the adoption of new investment vehicles, financial measures, and business practices that use technology to speed the supply of capital services and the efficiency of their

outcomes. Buy-in from key financial sector actors, in the form of regulatory comment periods and legislative inputs, is a critical measure to ensure successful implementation of these policies.

Risk and Resourcing: Creating and retaining talent in essential financial sectors to support the DoD Innovation Network requires investment in education, which is handled at the state and local levels in the United States. Costs may be effectively managed in communities with strong financial innovation ecosystems and academic centers, such as Boston, Austin, and Silicon Valley, where leading companies will be motivated to create and foster the talent they anticipate hiring in the future. Notably, Congress appropriated $17.5 billion in ESSA funding for FY22, an increase of $1 billion from FY21.[92] Program costs for start-up entrepreneurs will be covered by visa fees. There is minimal economic risk in expanding options for residency and immigration as research indicates such residents contribute significantly to the U.S. tax base and GDP growth. Not all possible visa beneficiaries will be eligible to contribute to DoD Innovation Network activities due to clearance requirements. Still, the U.S. must address talent shortages in the near-term while increasing home-grown science and research talent. Establishing norms and practices for U.S. financial regulations will create certainty in the market while reducing barriers and increasing the opportunity for financial flows. Risk associated with consumer protections for investors could be generated, but risk is necessary to ensure the most value added fintech technologies thrive in the marketplace. Established firms and systems cannot cover all of the risk, but such risks are necessary if the United States wants to lead the adoption of financial technology in the hopes of leading each stage of disruption to the global financial industry and benefitting from the resulting economic growth.

VII. Conclusion

The U.S. system for financing innovation in commercial markets is world-class, well-resourced, and robust. While innovation financing is a high-risk endeavor due to high start-up failure rates, uncertainty in technology, and the challenges inherent in scaling to market, it remains lucrative to the financial industry to support commercial innovation. Technological innovation, a favorable regulatory environment, and a foundation of human expertise are permeating industry and decreasing barriers and opportunity to capture capital. Alternative to the commercial market, the defense market is made more difficult with a single primary buyer in the DoD, a consolidating oligarchical defense industry, and low relative returns and scalability. All of these factors limit private finance's investments in new national security-oriented start-ups and have led to a divergence between high technology capabilities in the commercial marketplace and the outmoded technology often found within DoD and the broader USG. Continuation down a path without eliciting the additive capacity of private finance to improve defense solutions will prevent the DoD from keeping pace in the era of global competition.

VIII. Endnotes

[1] Vitor Gaspar and David Amaglobeli, "Fiscal Politics: A historic meeting laid the foundations of US finances," *Finance and Development*, March 2018, Vol. 55, No. 1, https://www.imf.org/external/pubs/ft/fandd/2018/03/gaspar.htm

[2] Vitor Gaspar and David Amaglobeli, "Fiscal Politics: A historic meeting laid the foundations of US finances," *Finance and Development*, March 2018, Vol. 55, No. 1, https://www.imf.org/external/pubs/ft/fandd/2018/03/gaspar.htm

[3] Board of Governors of the Federal Reserve System, "Money and Payments: The U.S. Dollar in the Age of Digital Transformation," January 2022, The Payment System, https://www.federalreserve.gov/publications/january-2022-cbdc.htm.

[4] President Joseph R. Biden, Jr., "Interim National Security Strategic Guidance," *The White House*, March 2021, https://www.whitehouse.gov/wp-content/uploads/2021/03/NSC-1v2.pdf; Jim Mattis, "Summary of the 2018 National Defense Strategy," n.d., 1–3., https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf.

[5] U.S. Bureau of Economic Analysis, "Real Gross Domestic Product," FRED, Federal Reserve Bank of St. Louis (FRED, Federal Reserve Bank of St. Louis, January 1, 1947), https://fred.stlouisfed.org/series/GDPC1.; World Bank, "Gross Domestic Product for China," FRED, Federal Reserve Bank of St. Louis (FRED, Federal Reserve Bank of St. Louis, January 1, 1960), https://fred.stlouisfed.org/series/MKTGDPCNA646NWDB.

[6] Mattis, "Summary of the 2018 National Defense Strategy," 1–3.

[7] "National Defense Strategy Includes Lessons Learned From Past 6 Months," U.S. Department of Defense, 2, accessed May 3, 2022, https://www.defense.gov/News/News-Stories/Article/Article/2956220/national-defense-strategy-includes-lessons-learned-from-past-6-months/.; "U.S. Strategy Toward the Russian Federation," U.S. Embassy in Estonia, August 22, 2018, https://ee.usembassy.gov/strategy-toward-russia/.; Mattis, "Summary of the 2018 National Defense Strategy," 2.

[8] "Defense-Innovation-Report.Pdf," 12–13, accessed May 3, 2022, https://innovation.mit.edu/assets/Defense-Innovation-Report.pdf.

[9] "U.S. Economy at a Glance | U.S. Bureau of Economic Analysis (BEA)," accessed May 3, 2022, https://www.bea.gov/news/glance.; "Https://Apps.Bea.Gov/ITable/ITable.Cfm?Reqid=19&step=2#reqid=19&step=2&isuri=1&1921=survey," accessed May 3, 2022, https://apps.bea.gov/iTable/iTable.cfm?reqid=19&step=2#reqid=19&step=2&isuri=1&1921=survey.; "Global R&D expenditures, by region: 2019", National Center for Science and Engineering Statistics | NSB 2022-5, accessed May 2, 2022, https://ncses.nsf.gov/pubs/nsb20225/assets/cross-national-comparisons-of-r-d-performance/figures/nsb20225-figrd-005.pdf; "Chart of the Day: This Is How the $88 Trillion Global Economy Is Spread around the World," World Economic Forum, accessed May 3, 2022, https://www.weforum.org/agenda/2020/10/global-economy-gdp-growth-covid-19/.

[10] "Global Financial Services Market Outlook 2021-2030; Expected to Reach $28.52 Trillion by 2025 - ResearchAndMarkets.Com," March 10, 2021, https://www.businesswire.com/news/home/20210310005386/en/Global-Financial-Services-Market-Outlook-2021-2030-Expected-to-Reach-28.52-Trillion-by-2025---ResearchAndMarkets.com.

[11] MarketLine, *MarketLine Industry Profile: Global Financial Technology Market (FinTech)*, June 2020; 11, 15, https://advantage-marketline-com.nduezproxy.idm.oclc.org/Analysis/ViewasPDF/global-financial-technology-market(fintech)-127429.; Insider Intelligence, "Overview of the Fintech Industry: Stats, Trends, and Companies in the Ecosystem Market Research Report," Business Insider, accessed February 5, 2022, https://www.businessinsider.com/fintech-ecosystem-report.; "Global Financial Services Market Outlook 2021-2030; Expected to Reach $28.52 Trillion by 2025 - ResearchAndMarkets.Com." Peter Reynolds and Gina Primeaux, "Disruptive digital technologies in the financial services industry," *Deloitte.*, accessed on May 12, 2022, https://www2.deloitte.com/us/en/pages/financial-services/articles/disruptive-digital-technologies-in-the-financial-services-industry.html.

[12] "U.S. R&D Increased by $51 Billion, to $606 Billion, in 2018; Estimate for 2019 Indicates a Further Rise to $656 Billion | NSF - National Science Foundation," accessed May 3, 2022, https://ncses.nsf.gov/pubs/nsf21324.

[13] John F Sargent Jr, "U.S. Research and Development Funding and Performance: Fact Sheet," *Fact Sheet*, n.d., 2-3.

[14] Gil Press, "Angel Investors Are The Unsung Catalysts Of U.S. Innovation And Growth," Forbes, accessed May 3, 2022, https://www.forbes.com/sites/gilpress/2021/10/05/angel-investors-are-the-unsung-catalysts-of-us-innovation-

and-growth/.; "Bain_report_global-Private-Equity-Report-2022.Pdf," 2, accessed May 3, 2022, https://www.bain.com/globalassets/noindex/2022/bain_report_global-private-equity-report-2022.pdf.; "As More VC Money Floods into Fertility, Some Startups Are Feeling Left out | PitchBook," accessed May 3, 2022, https://pitchbook.com/news/articles/venture-capital-fertility-technology-femtech.; "Six Charts That Show 2021's Record Year for US Venture Capital | PitchBook," accessed May 3, 2022, https://pitchbook.com/news/articles/2021-record-year-us-venture-capital-six-charts.; "How Does 10x Get It Done? Explore Our Process | 10x.Gsa.Gov," 10x - Funding Ideas for Better Public Service, accessed May 3, 2022, https://10x.gsa.gov/process/.

[15] "Bain_report_global-Private-Equity-Report-2022.Pdf," 9.; Press, "Angel Investors Are The Unsung Catalysts Of U.S. Innovation And Growth."; "Six Charts That Show 2021's Record Year for US Venture Capital | PitchBook," accessed May 3, 2022, https://pitchbook.com/news/articles/2021-record-year-us-venture-capital-six-charts.

[16] "Bain_report_global-Private-Equity-Report-2022.Pdf," 9.; Press, "Angel Investors Are The Unsung Catalysts Of U.S. Innovation And Growth."; "Six Charts That Show 2021's Record Year for US Venture Capital | PitchBook."

[17] "Six Charts That Show 2021's Record Year for US Venture Capital | PitchBook," accessed May 4, 2022, https://pitchbook.com/news/articles/2021-record-year-us-venture-capital-six-charts.

[18] "Unicorns Are the Rarest Startups Around," accessed May 18, 2022, https://republic.com/blog/investor-education/unicorns-are-the-rarest-startups-around.

[19] "Six Charts That Show 2021's Record Year for US Venture Capital | PitchBook."; "The Private Equity Market in 2021: The Allure of Growth," Bain, March 7, 2022, https://www.bain.com/insights/private-equity-market-in-2021-global-private-equity-report-2022/.; "Bain_report_global-Private-Equity-Report-2022.Pdf," 12.

[20] Various, "State-of-Competition-Within-the-Defense-Industrial-Base," *Department of Defense*, n.d., 4.

[21] Various, 4.

[22] Congressional Research Service, "Who Regulates Whom? An Overview of the U.S. Regulatory Framework," Summary, Updated March 10, 2020, https://sgp.fas.org/crs/misc/R44918.pdf.

[23] Congressional Research Service, Who Regulates Whom?"

[24] Murray Newlands, "Pros and Cons of Using an Angel Investor to Fund a Startup," https://www.startupgrind.com/blog/pros-and-cons-of-using-an-angel-investor-to-fund-a-startup/.

[25] Mrinal Menon and Jeff Decker, "Why the defense industry could be the most transformative market for startups," Fast Company, May 10, 2021, https://www.fastcompany.com/90634168/why-the-defense-industry-could-be-the-most-transformative-market-for-startups.

[26] Mrinal Menon and Jeff Decker, "Why the defense industry could be the most transformative market for startups," Fast Company, May 10, 2021, https://www.fastcompany.com/90634168/why-the-defense-industry-could-be-the-most-transformative-market-for-startups.

[27] The National Science Foundation and the National Science Board, "The State of U.S. Science and Engineering 2020," National Center for Science and Engineering Statistics, January 2020, https://ncses.nsf.gov/pubs/nsb20201/executive-summary.

[28] J.H. Cullum Clark, "Why America's Freek Market Economy Works Better *in* Some Places *than* Others," *The Catalyst: A Journal of Ideas from the Bush Institute*, Fall 2019, Issue 16, https://www.bushcenter.org/catalyst/capitalism/clark-why-americas-free-market-economy-works-better-in-some-places-than-others.html

[29] "Global Entrepreneurship Monitor 2021/2022 Global Report: Opportunity Amid Disruption," n.d., 44.

[30] Carl Benedikt Frey, "How Culture Gives the US an Innovation Edge Over China," *MIT Sloan Management Review*, Magazine Spring 2021 Issue, February 8, 2021, https://sloanreview.mit.edu/article/how-culture-gives-the-us-an-innovation-edge-over-china/

[31] Dutta Soumitra et al., "Global Innovation Index Innovation Trends and Report" (World Intellectual Property Organziation, 2021), 167, https://doi.org/10.34667/TIND.44315.

[32] Soumitra et al., "Global Innovation Index 2021 Report."

[33] "2020 Banking Industry Outlook | Deloitte US," accessed May 10, 2022, https://www2.deloitte.com/us/en/pages/financial-services/articles/banking-industry-outlook.html.

[34] Will Thomas, "Congress Passes National Defense Authorization Act for Fiscal Year 2022," American Institute of Physics, December 15, 2021, https://www.aip.org/fyi/2022/congress-passes-national-defense-authorization-act-fiscal-year-2022.

[35] Will Thomas, "Congress Passes National Defense Authorization Act for Fiscal Year 2022," American Institute og Physics, December 15, 2021, https://www.aip.org/fyi/2022/congress-passes-national-defense-authorization-act-fiscal-year-2022.
[36] "Fiscal 2020 Pentagon Contracting Hits Record $445 Billion," *Bloomberg Government* (blog), accessed May 18, 2022, https://about.bgov.com/news/fiscal-2020-pentagon-contracting-hits-record-445-billion/.
[37] Congressional Research Service, *U.S. Research and Development Funding and Performance: Fact Sheet*, John F. Sargent Jr. R44307, October 2021, https://sgp.fas.org/crs/misc/R44307.pdf.
[38] National Center for Science and Engineering Statistics, *Federal Funds for Research and Development: Fiscal Years 2020–21,* Table 9. National Science Foundation, https://ncses.nsf.gov/pubs/nsf22323.
[39] Institute for Defense & Business, "What is the Defense Industrial Base?," accessed on May 18, 2022, https://www.idb.org/what-is-the-defense-industrial-base/.
[40] Congressional Research Service, "Defense Primer: Department of Defense Contractors," Updated December 17, 2021, https://sgp.fas.org/crs/natsec/IF10600.pdf. The five primes are: : Lockheed Martin, Boeing, Raytheon, General Dynamics, and Northrop Grumman.
[41] Joanna Glasner, "Inside The US Military And Defense Sectors: The VC-Backed Companies Getting Jobs And The Big Contractors Funding Startups," Crunchbase News, March 15, 2022, https://news.crunchbase.com/news/military-defense-sector-venture-startups-spacex/ .
[42] "Tapping into Commercial Technologies in Support of Innovation," Lockheed Martin, June 22, 2020, https://www.lockheedmartin.com/en-us/news/features/2020/lockheed-martin-ventures-emerging-technology.html.
[43] Richard Harroch, "What Angel Investors Want To Know Before Investing in Your Startup," Forbes, December 13, 2020. https://www.forbes.com/sites/allbusiness/2020/12/13/what-angel-investors-want-to-know-before-investing-in-your-startup/?sh=5de43db41a11.
[44] Murray Newlands, "Pros and Cons of Using an Angel Investor to Fund a Startup," https://www.startupgrind.com/blog/pros-and-cons-of-using-an-angel-investor-to-fund-a-startup/.
[45] Dave Brkus and JD Davids, "The Valley of Death for Statips." Smartmoney Startups, October 18, 2017, https://www.smartmoneystartups.com/the-valley-of-death-for-startups-dave-berkus/.
[46] Narbe Alexandrian, "Unreaveling the venture capital timeline," RIV Capital, November 23, 2020, https://www.rivcapital.com/the-deep-end/blog-details/the-deep-end/2020/11/23/unravelling-the-venture-capital-timeline.
[47] Gene Teare, "Lessons From 20028: How The Downturn Impacted Funding Two To Four Years Out," Crunchbase, March 24, 2020, https://news.crunchbase.com/news/lessons-from-2008-how-the-downturn-impacted-funding-two-to-four-years-out/.
[48] "Private Equity vs. Venture Capital: What's the Difference?," Investopedia, accessed May 18, 2022, https://www.investopedia.com/ask/answers/020415/what-difference-between-private-equity-and-venture-capital.asp.
[49] Catherine Cote, "3 Key Types of Private Equity Strategies," Harvard Business School Online, July 13, 2021, https://online.hbs.edu/blog/post/types-of-private-equity.
[50] Corporate Finance Institute (CFI), "Corporate Venturing – Directly investing corporate funds into external startup companies," https://corporatefinanceinstitute.com/resources/knowledge/finance/corporate-venturing-corporate-venture-capital/.
[51] Corporate Finance Institute (CFI), "Corporate Venturing – Directly investing corporate funds into external startup companies, https://corporatefinanceinstitute.com/resources/knowledge/finance/corporate-venturing-corporate-venture-capital/.
[52] "Venture Debt: How It Works | Silicon Valley Bank," accessed May 12, 2022, https://www.svb.com/startup-insights/venture-debt/how-does-venture-debt-work.
[53] "Venture Debt."
[54] "Venture Debt."
[55] Dr. Phil Budden and Prof. Fiona Murray, "Defense Innovation Report: Applying MIT's Innovation Ecosystem & Stakeholder Approach to Innovation in Defense on a Country-By-Country Basis," *MIT Lab for Innovation Science and Policy*, May 2019, 13, https://innovation.mit.edu/assets/Defense-Innovation-Report.pdf.
[56] "Renewing Defense Innovation: Five Incentives for Forming Pentagon-Startup Partnerships," War on the Rocks, May 3, 2018, https://warontherocks.com/2018/05/renewing-defense-innovation-five-incentives-for-forming-pentagon-startup-partnerships/.; "Private Capital Crucial for Defense Innovation," accessed May 3, 2022, https://www.nationaldefensemagazine.org/articles/2021/4/23/private-capital-crucial-for-defense-innovation.;

Venture capital community leaders, "The Defense Industry Needs New Entrants, and a Supportive Government during Crises," Defense News, May 4, 2020, https://www.defensenews.com/opinion/commentary/2020/05/04/the-defense-industry-needs-new-entrants-and-a-supportive-government-during-crises/.

[57] "Business Opportunities – Defense Innovation Marketplace," accessed May 3, 2022, https://defenseinnovationmarketplace.dtic.mil/business-opportunities/.; "Work With Us," accessed May 3, 2022, https://www.diu.mil/work-with-us.; "Home," accessed May 3, 2022, https://www.secnav.navy.mil/agility/Pages/Archive/default.aspx.; "Army Futures Command on LinkedIn: #TeamAFC #ForgeTheFuture #Army," accessed May 3, 2022, https://www.linkedin.com/feed/update/urn:li:activity:6924706389370048512.; "Army Venture Capital Corporation (AVCC)," accessed May 3, 2022, https://www.army.vc/.; "SOFWERX," accessed May 3, 2022, https://www.sofwerx.org/.;

[58] "Business Opportunities – Defense Innovation Marketplace."; "Work With Us."; "Home."; "Army Futures Command on LinkedIn."; "Army Venture Capital Corporation (AVCC)."; "SOFWERX.";

[59] Mrinal Menon and Jeff Decker, "Why the defense industry could be the most transformative market for startups," Fast Company, May 10, 2021, https://www.fastcompany.com/90634168/why-the-defense-industry-could-be-the-most-transformative-market-for-startups.

[60] "About | SBIR.Gov," accessed May 18, 2022, https://www.sbir.gov/about.

[61] "The U.S. Defense Industry in a New Era," War on the Rocks, January 13, 2021, https://warontherocks.com/2021/01/the-u-s-defense-industry-in-a-new-era/.

[62] Tom McCuin, "The Real Reason Small Businesses Struggle to Win Defense Contracts," ClearanceJobs, July 26, 2017, https://news.clearancejobs.com/2017/07/26/real-reason-small-businesses-struggle-win-defense-contracts/.

[63] "DoD Seeks $100M for 'Valley of Death' Bridge Fund," accessed May 3, 2022, https://www.yahoo.com/now/dod-seeks-100m-valley-death-141147001.html.; "Fear Not the Demise of Venture Capital Funding for Defense," War on the Rocks, May 3, 2022, https://warontherocks.com/2022/05/fear-not-the-demise-of-venture-capital-funding-for-defense/.

[64] "Fear Not the Demise of Venture Capital Funding for Defense."; "DoD Seeks $100M for 'Valley of Death' Bridge Fund."; "Fear Not the Demise of Venture Capital Funding for Defense."

[65] "DoDs new R&D chief prioritizes moving prototypes to real world applications," accessed 03 May 2022, https://federalnewsnetwork.com/on-dod/2021/10/dods-new-rd-chief-prioritizes-moving-prototypes-to-real-world-applications/

[66] "DoDs new R&D chief prioritizes moving prototypes to real world applications," accessed 03 May 2022, https://federalnewsnetwork.com/on-dod/2021/10/dods-new-rd-chief-prioritizes-moving-prototypes-to-real-world-applications/

[67] "DoD seeks $100M for 'valley of death' bridge fund," accessed 03 May 2022, https://www.defensenews.com/pentagon/2022/04/07/dod-seeks-100m-for-valley-of-death-bridge-fund/

[68] Bani Sapra, "A Group of VCs Warn That Funding for Defense Startups Will Dry up Unless Government Agencies Take Action: 'Give Contracts, Not Lip Service,'" Business Insider, accessed May 3, 2022, https://www.businessinsider.com/vcs-warn-no-defense-funding-without-contracts-2020-5.; Aaron Mehta, "'The Math Doesn't Make Sense': Why Venture Capital Firms Are Wary of Defense-Focused Investments," Defense News, January 30, 2020, https://www.defensenews.com/smr/cultural-clash/2020/01/30/the-math-doesnt-make-sense-why-venture-capital-firms-are-wary-of-defense-focused-investments/.; "3 VCs That Know Federal," *Dcode* (blog), June 22, 2021, https://dcode.co/blog/vcs-that-know-federal/.

[69] Sapra, "A Group of VCs Warn That Funding for Defense Startups Will Dry up Unless Government Agencies Take Action."; Mehta, "'The Math Doesn't Make Sense.'"; "3 VCs That Know Federal."

[70] "Agile Culture in the DoD," n.d., 2.; "'Agile' Is Not Quite Agile for DOD, and Other Familiar Acquisition Problems Persist, Watchdog Finds," FedScoop, June 16, 2020, https://www.fedscoop.com/agile-cybersecurity-cost-over-run-annual-gao-report/.

[71] C. Todd Lopez, "DoD Modernization Can't Happen Alone, Defense Officials Say," U.S. Department of Defense, April 13, 2021, https://www.defense.gov/News/News-Stories/Article/Article/2571576/dod-modernization-cant-happen-alone-defense-official-says/.

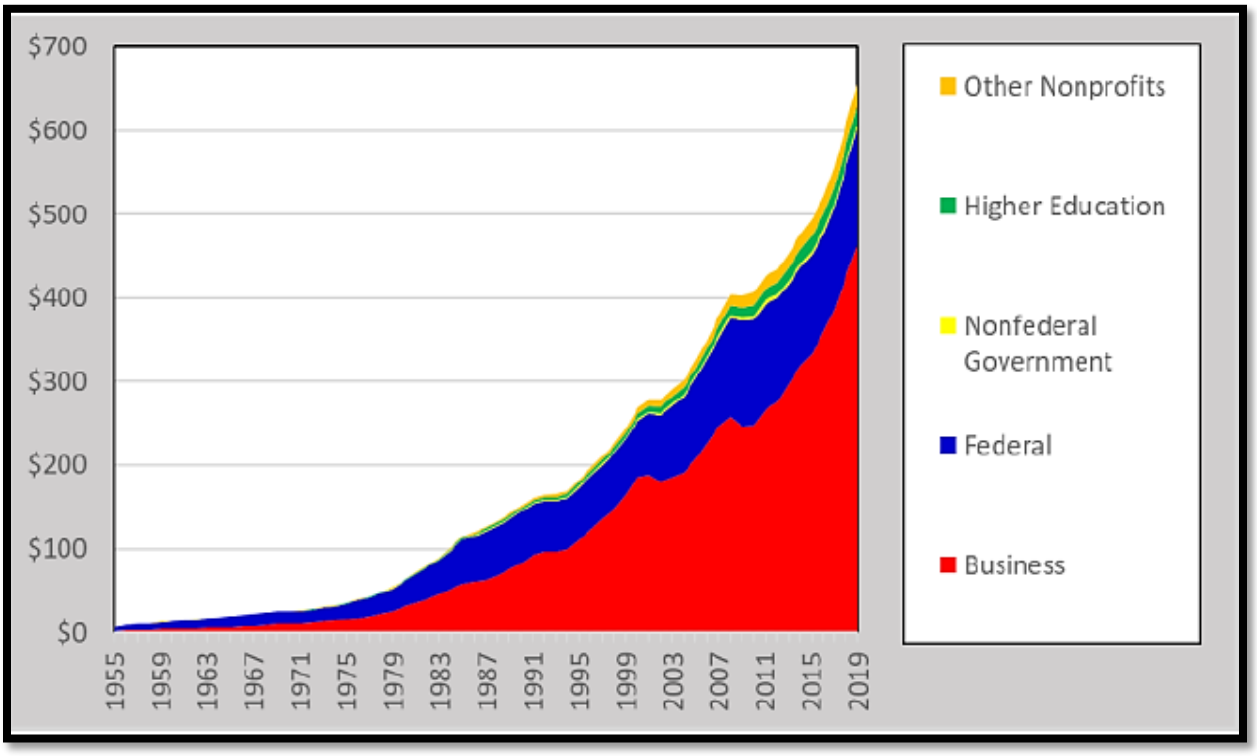
[72] Debra Werner, "Military tirns to private sector for rapid space innovation," Space News, October 9, 2019, https://spacenews.com/warfare-satellite-innovation-2019/.

[73] Debra Werner, "Military tirns to private sector for rapid space innovation," Space News, October 9, 2019, https://spacenews.com/warfare-satellite-innovation-2019/.

[74] Debra Werner, "Military tirns to private sector for rapid space innovation," Space News, October 9, 2019, https://spacenews.com/warfare-satellite-innovation-2019/.
[75] "15 U.S. Code § 638 - Research and Development," LII / Legal Information Institute, accessed May 19, 2022, https://www.law.cornell.edu/uscode/text/15/638.
[76] "The U.S. Must Improve K-12 STEM Education for All," National Science Board, Science & Engineeering Indicators 2022, National Science Foundation, accessed on May 10, 2022, https://www.nsf.gov/nsb/sei/one-pagers/K-12-Indicator-2022.pdf.
[77] Boris Granovskiy and Jill H. Wilson, "Foreign STEM Students in the United States," *Congressional Research Service*, November 1, 2019, https://crsreports.congress.gov/product/pdf/IF/IF11347.
[78] Boris Granovskiy and Jill H. Wilson, "Foreign STEM Students in the United States," *Congressional Research Service*, November 1, 2019, https://crsreports.congress.gov/product/pdf/IF/IF11347.
[79] Brigid O'Rourke, "Growing gap in STEM supply and demand," *The Harvard Gazette*, November 18, 2021, https://news.harvard.edu/gazette/story/2021/11/increasing-access-and-opportunity-in-stem-crucial-say-experts/.
[80] "Under Secretary of Defense (Comptroller) > Budget Materials > Budget2022," accessed May 19, 2022, https://comptroller.defense.gov/Budget-Materials/Budget2022/.
[81] John F Sargent, "Global Research and Development Expenditures: Fact Sheet" (Congressional Research Services, September 27, 2021), https://sgp.fas.org/crs/misc/R44283.pdf.
[82] Heidi M Peters, "Defense Primer: The National Technology and Industrial Base," n.d., 3.
[83] Laura Silver et al., "In U.S. and UK, Globalization Leaves Some Feeling 'Left Behind' or 'Swept Up,'" *Pew Research Center's Global Attitudes Project* (blog), October 5, 2020, https://www.pewresearch.org/global/2020/10/05/in-u-s-and-uk-globalization-leaves-some-feeling-left-behind-or-swept-up/.
[84] "DOE Loan Programs Office Backs Loan Guarantees to Foster Innovation and Achieve 2050 Net Zero Carbon Economy," Perkins Coie, accessed May 6, 2022, https://www.perkinscoie.com/en/news-insights/doe-loan-programs-office-backs-loan-guarantees-to-foster-innovation-and-achieve-2050-net-zero-carbon-economy.html.
[85] "Under Secretary of Defense (Comptroller) > Budget Materials > Budget2022."
[86] cno2, "MEP National Network," text, NIST, September 3, 2014, https://www.nist.gov/mep/mep-national-network; "Institutes," Manufacturing USA, accessed May 18, 2022, https://www.manufacturingusa.com/institutes.
[87] STEM Education Coalition, "Federal Policy Goals," January 2021, 2 - 4, http://www.stemedcoalition.org/wp-content/uploads/2021/02/STEM-Ed-Coalition-2021-Federal-Priorities-Final.pdf.
[88] STEM Education Coalition, "Federal Policy Goals," January 2021, 2 - 4, http://www.stemedcoalition.org/wp-content/uploads/2021/02/STEM-Ed-Coalition-2021-Federal-Priorities-Final.pdf.
[89] Intel, "Promoting STEM Education: She Will Connect," accessed on May 19, 2022, https://www.intel.com/content/www/us/en/corporate-responsibility/promoting-stem-education.html; JP Morgan Chase & Co, "The Schools Challenge," accessed on May 19, 2022, https://www.jpmorganchase.com/news-stories/the-schools-challenge.
[90] "Study: Immigrants in the U.S. Are More Likely to Start Firms, Create Jobs," MIT News | Massachusetts Institute of Technology, accessed May 18, 2022, https://news.mit.edu/2022/study-immigrants-more-likely-start-firms-create-jobs-0509.
[91] "FACT SHEET: President Biden to Sign Executive Order on Ensuring Responsible Development of Digital Assets," The White House, March 9, 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/03/09/fact-sheet-president-biden-to-sign-executive-order-on-ensuring-responsible-innovation-in-digital-assets/.
[92] First Five Years Funds, "Every Student Succeeds Act," Recent Updates, accessed on May 19, 2022, https://www.ffyf.org/issues/essa/.

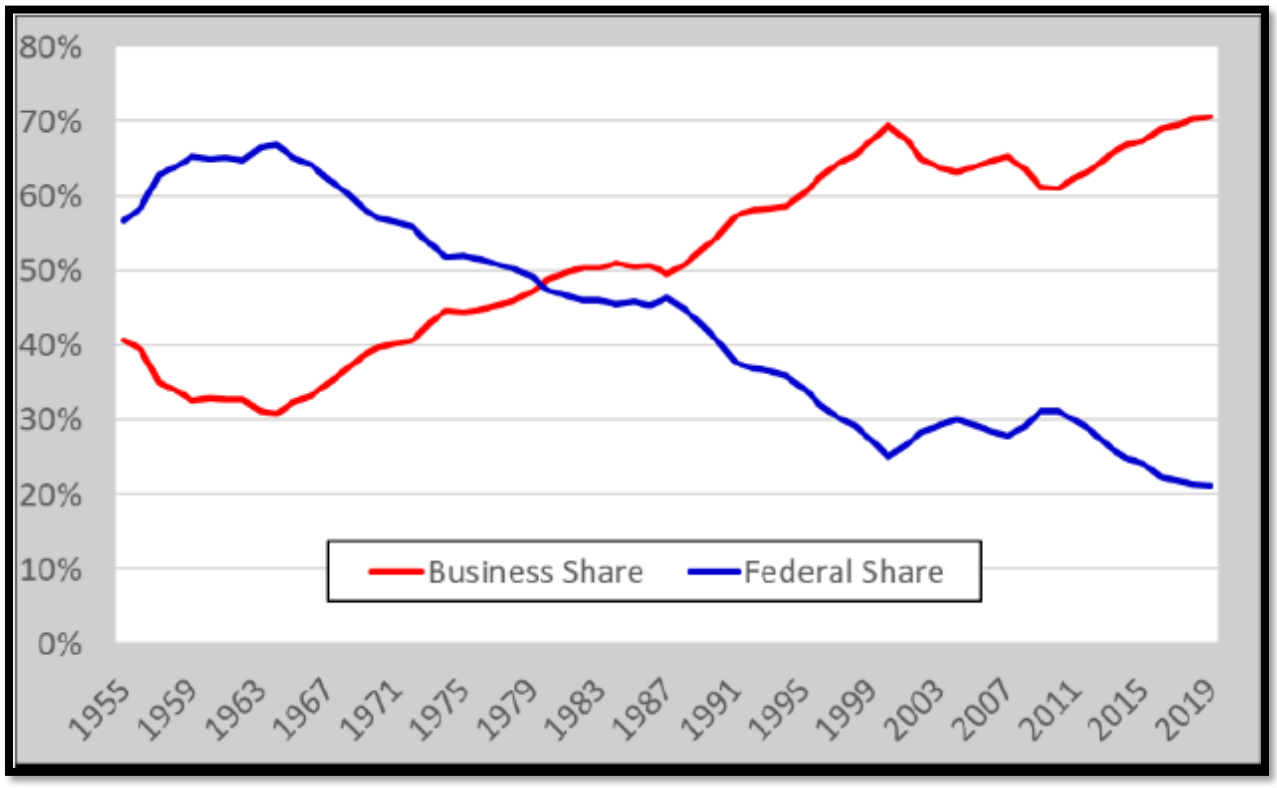
Appendix A: Supporting Charts, Graphs, and Figures

Figure 1: U.S. R&D Expenditures by Source of Funding, 1955-2019 (Current Billions of USD)



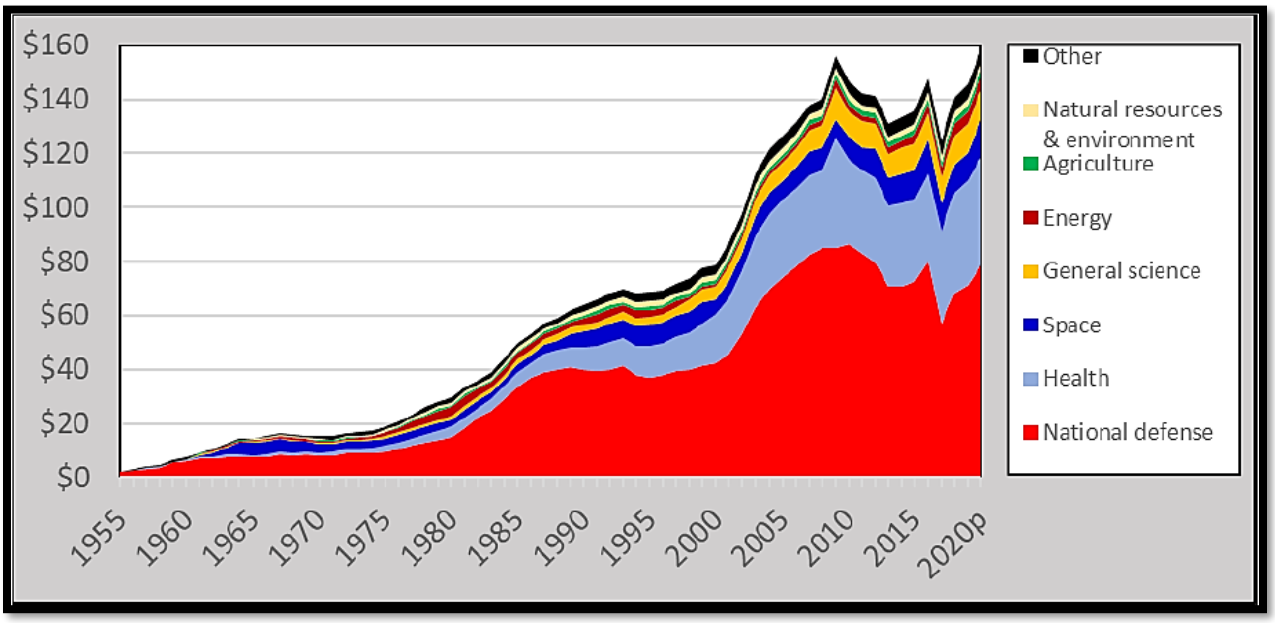
Source: John F. Sargent Jr., "U.S. Research and Development Funding and Performance: Fact Sheet," *Congressional Research Service*, October 4, 2021, 1, https://crsreports.congress.gov/product/pdf/R/R44307

Figure 2: Federal and Business Shares of U.S. R&D Expenditures, 1955-2019



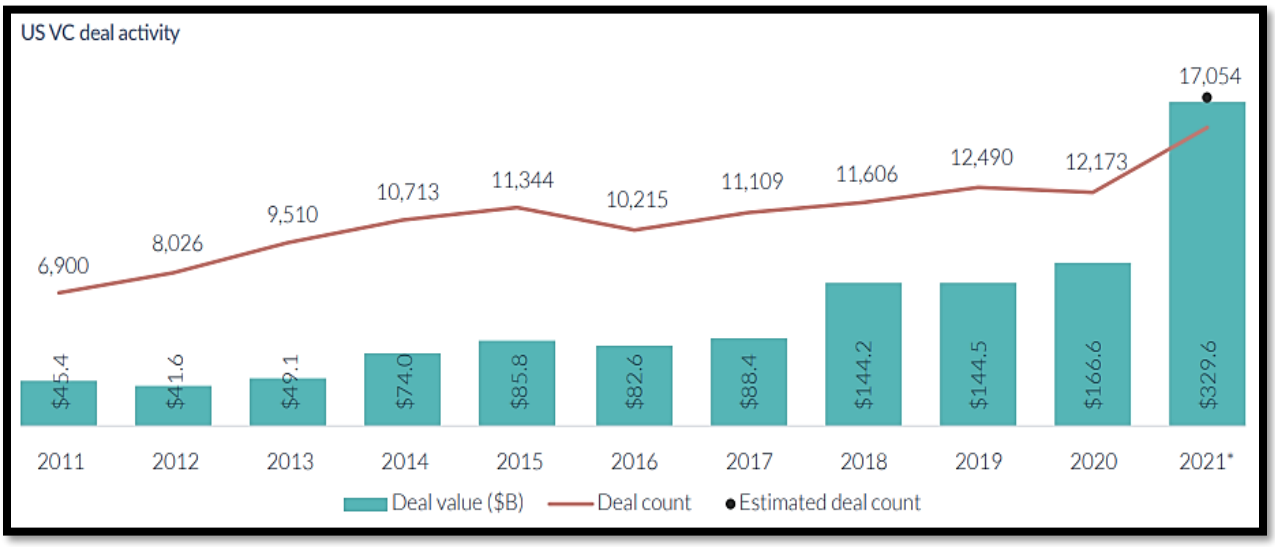
Source: John F. Sargent Jr., "U.S. Research and Development Funding and Performance: Fact Sheet," *Congressional Research Service*, October 4, 2021, 2, https://crsreports.congress.gov/product/pdf/R/R44307; CRS analysis of National Science Foundation, National Patterns of R&D Resources: 2018– 19 Data Update, NSF 21-325, Table 6, April 9, 2021, https://ncses.nsf.gov/pubs/nsf21325.

Figure 3: Federal R&D Funding by Budget Function, 1955-2020 (Current Billions of USD)



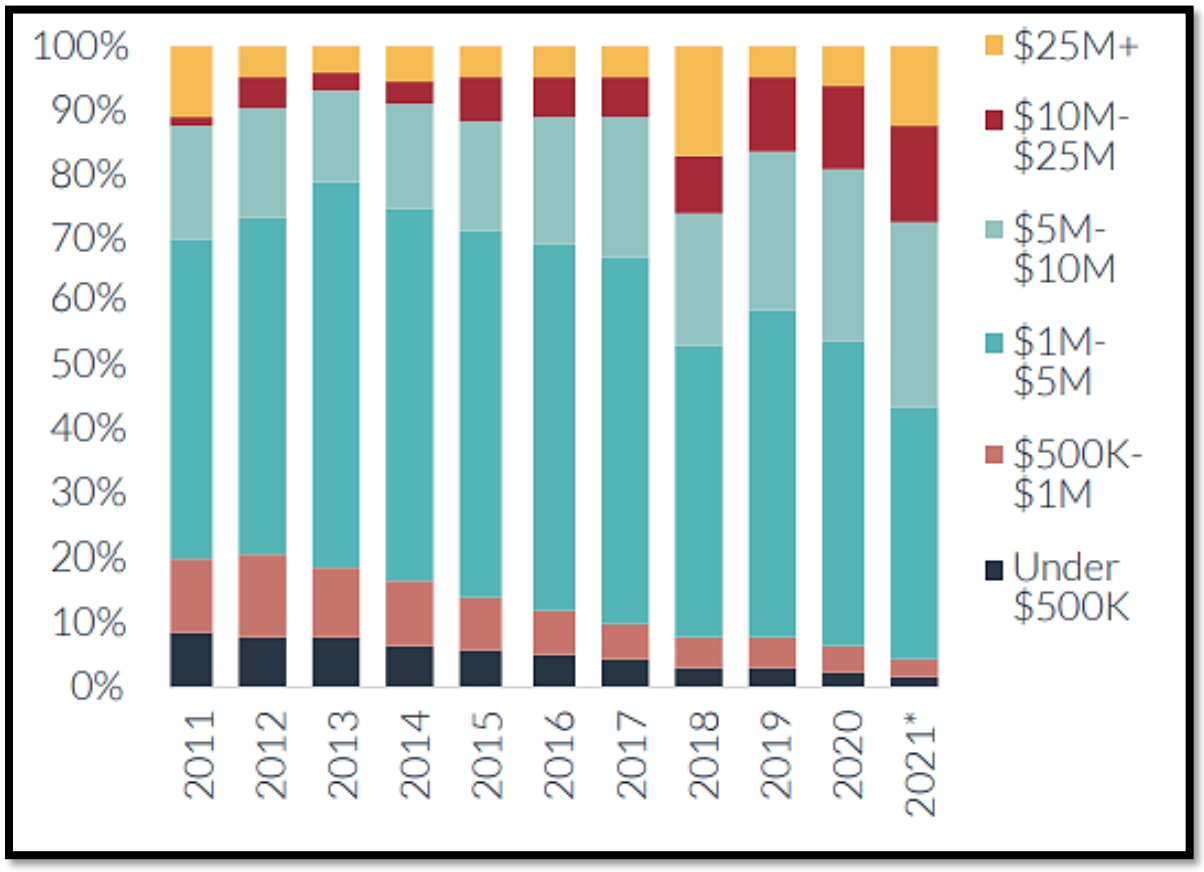
Source: John F. Sargent Jr., "U.S. Research and Development Funding and Performance: Fact Sheet," *Congressional Research Service*, October 4, 2021, 2, https://crsreports.congress.gov/product/pdf/R/R44307; CRS analysis of data from National Science Foundation, *Federal R&D Funding, by Budget Function: Fiscal Years 2019–21*, (NSF 21-315), Table 23, February 22, 2021, https://ncses.nsf.gov/pubs/nsf21315.

Figure 4: Financial Trends in Venture Capital Investment, 2011-2021



Source: "Venture Monitor, Q4, 2021," *PitchBook-NVCA*, January 14, 2022, 5, https://files.pitchbook.com/website/files/pdf/Q4_2021_PitchBook_NVCA_Venture_Monitor.pdf .

Figure 5: U.S. Angel Investor and Venture Capital Seed Deal Value by Size Bucket



Source: "Venture Monitor, Q4, 2021," *PitchBook-NVCA*, January 14, 2022, 8, https://files.pitchbook.com/website/files/pdf/Q4_2021_PitchBook_NVCA_Venture_Monitor.pdf

Table 1: USG Department/Service SBIR Compliance Data

Agency	Measure	FY19	FY18	FY17	FY16
HHS	SBIR Obs	$1,020,122,644	$930,888,048	$885,737,322	$773,384,238
	Extramural Funding	$31,918,190,453	$29,317,202,304	$27,455,557,340	$25,859,796,811
	%	3.20%	3.18%	3.23%	2.99%
DOE	SBIR Obs	$267,956,532	$249,323,167	$223,735,470	$199,642,873
	Extramural Funding	$7,622,095,182	$7,516,567,038	$6,903,792,000	$6,528,019,000
	%	3.52%	3.32%	3.24%	3.06%
NSF	SBIR Obs	$188,185,336	$184,752,161	$174,463,775	$161,577,024
	Extramural Funding	$5,633,324,088	$5,588,420,000	$5,440,330,000	$5,444,000,000
	%	3.34%	3.31%	3.21%	2.97%
NASA	SBIR Obs	$162,182,727	$166,067,230	$155,799,248	$163,327,061
	Extramural Funding	$5,251,439,862	$4,647,180,884	$3,590,595,217	$6,036,000,000
	%	3.09%	3.57%	4.34%	2.71%
DHS	SBIR Obs	$21,987,108	$17,101,472	$19,649,785	$16,967,146
	Extramural Funding	$483,760,085	$475,336,046	$401,793,643	$390,303,540
	%	4.55%	3.60%	4.89%	4.35%
USDA	SBIR Obs	$21,551,701	$29,255,092	$26,279,245	$28,801,636
	Extramural Funding	$877,675,473	$980,934,931	$854,345,150	$707,988,706
	%	2.46%	2.98%	3.08%	4.07%
DOT	SBIR Obs	$11,119,743	$5,355,303	$11,538,474	$11,617,647
	Extramural Funding	$301,669,000	$303,634,000	$253,519,000	$309,371,000
	%	3.69%	1.76%	4.55%	3.76%
DOC	SBIR Obs	$10,296,573	$15,220,161	$11,386,389	$12,466,445
	Extramural Funding	$322,537,000	$416,155,800	$434,093,000	$283,376,400
	%	3.19%	3.66%	2.62%	4.40%
ED	SBIR Obs	$10,190,350	$8,379,685	$7,944,493	$7,506,669
	Extramural Funding	$225,442,779	$265,242,372	$246,082,497	$230,646,029
	%	4.52%	3.16%	3.23%	3.25%
EPA	SBIR Obs	$5,641,564	$3,584,553	$3,708,925	$4,908,234
	Extramural Funding	$115,186,100	$111,037,700	$111,349,800	$155,552,700
	%	4.90%	3.23%	3.33%	3.16%
Air Force	SBIR Obs	$561,325,318	$286,323,683	$288,377,347	$316,852,660
	Extramural Funding	$21,731,612,021	$18,132,704,918	$6,320,322,000	$9,761,877,658
	%	2.58%	1.58%	4.56%	3.25%
Navy	SBIR Obs	$467,008,352	$370,154,893	$299,173,927	$297,689,393
	Extramural Funding	$11,201,516,556	$10,649,337,236	$11,181,185,350	$10,120,425,993
	%	4.17%	3.48%	2.68%	2.94%
Army	SBIR Obs	$216,421,394	$200,159,660	$224,799,018	$123,031,546
	Extramural Funding	$8,312,886,000	$7,783,366,000	$9,250,397,000	$6,400,978,000
	%	2.60%	2.57%	2.43%	1.92%
Other OSD	SBIR Obs	$327,532,501	$309,661,728	$340,816,963	$244,265,748
	Extramural Funding	$10,440,882,351	$12,376,296,530	Not Reported	$10,419,251,442
	%	3.14%	2.50%	Not Reported	2.34%
Civilian Agencies	SBIR Obs	$1,719,234,278	$1,609,926,872	$1,520,243,126	$1,380,198,973
	Extramural Funding	$52,751,320,022	$49,621,711,075	$45,691,457,647	$45,945,054,186
	%	3.26%	3.24%	3.33%	3.00%
Defense Agencies	SBIR Obs	$1,572,287,565	$1,166,299,964	$812,350,292	$981,839,347
	Extramural Funding	$51,686,896,928	$48,941,704,684	$26,751,904,350	$36,702,533,093
	%	3.04%	2.38%	3.04%	2.68%
All Agencies	SBIR Obs	$3,291,521,843	$2,776,226,836	$2,332,593,418	$2,362,038,320
	Extramural Funding	$104,438,216,950	$98,563,415,759	$72,443,361,997	$82,647,587,279
	%	3.15%	2.82%	3.22%	2.86%
Min % Requirement		3.2%	3.2%	3.2%	3.0%
Theoretical DoD SBIR Obligation Shortfall		**$81,693,137**	**$399,834,586**	**$43,710,647**	**$119,236,646**

Source: "SBIR Execution Data" *FY19, 18, 17, 16 Individual Reports*, accessed May 13, 2022, https://www.sbir.gov/annual-reports-files

Appendix B: Glossary

Capital Stack - Authors' definition. For the purpose of this paper, capital stack refers to the various financing types available to start-ups, including angel investors, venture capital, private equity, government funding, etc.

Dilution[1] - Dilution occurs when a company issues new shares that result in a decrease in existing stockholders' ownership percentage of that company. Stock dilution can also occur when holders of stock options, such as company employees, or holders of other optionable securities exercise their options. When the number of shares outstanding increases, each existing stockholder owns a smaller, or diluted, percentage of the company, making each share less valuable.

Financial Technology[2] - Financial technology (Fintech) is used to describe new tech that seeks to improve and automate the delivery and use of financial services. At its core, fintech is utilized to help companies, business owners and consumers better manage their financial operations, processes, and lives by utilizing specialized software and algorithms that are used on computers and, increasingly, smartphones. Fintech, the word, is a combination of "financial technology".

Founder - An individual who develops a product or service that is the basis for company formation. Most often refers to the person or persons who form a start-up company.

Independent Research and Development (IRAD)[3] - Independent Research and Development (IRAD) is an allowable cost that allows companies to initiate and conduct research and development (R&D) projects of potential interest to DoD and is reimbursed through overhead cost rates.

Innovation Ecosystem[4] - An innovation ecosystem is the network of organizations—including suppliers, distributors, customers, competitors, government agencies, and so on—involved in the delivery of innovative products or services through both competition and cooperation. The idea is that each entity in the ecosystem affects and is affected by the others, creating a constantly evolving relationship in which each entity must be flexible and adaptable in order to survive as in a biological ecosystem. Definition modified from Investopedia's 'business ecosystem' definition.

Loan Guarantee[5] - A loan guarantee, in finance, is a promise by one party (the guarantor) to assume the debt obligation of a borrower if that borrower defaults. A guarantee can be limited or unlimited, making the guarantor liable for only a portion or all of the debt.

Program Element Code[6] - The Program Element (PE) is the primary data element in the Future Year Defense Program (FYDP) and is the foundation of the PPBE Process. Each program and entity within the defense portfolio has its own PE and is the specific allocation of resources for those entities from the Secretary of Defense.

Risk Capital[7] - Risk capital refers to funds allocated to speculative activity and used for high-risk, high-reward investments. Any money or assets that are exposed to a possible loss in value is considered risk capital, but the term is often reserved for those funds earmarked for highly speculative investments.

SBIR and STTR[8] - The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are highly competitive programs that encourage domestic small businesses to engage in Federal Research/Research and Development (R/R&D) with the potential for commercialization. Through a competitive awards-based program, SBIR and STTR enable small businesses to explore their technological potential and provide the incentive to profit from its commercialization. By including qualified small businesses in the nation's R&D arena, high-tech innovation is stimulated, and the United States gains entrepreneurial spirit as it meets its specific research and development needs.

Start-up[9] - The term start-up refers to a company in the first stages of operations. Start-ups are founded by one or more entrepreneurs who want to develop a product or service for which they believe there is demand. These companies generally start with high costs and limited revenue, which is why they look for capital from a variety of sources such as venture capitalists.

Sticky Contract – Authors' definition adapted from seminar engagements with start-up founders. A sticky contract is the term used by some in the start-up community that refers to the lure of an initial government contract that has a strong potential to lead to follow-on government contracts.

Technology Readiness Level (TRL)[10] - Technology Readiness Levels (TRL) are a type of measurement system used to assess the maturity level of a particular technology. Each technology project is evaluated against the parameters for each technology level and is then assigned a TRL rating based on the projects progress. There are nine technology readiness levels. TRL 1 is the lowest and TRL 9 is the highest.

Unicorn[11] - A term used in the venture capital industry to describe a privately held start-up company with a value of over $1 billion.

Valley of Death – For DoD, it is a journey (typically one to two years long for survivors) where a vendor transitions a prototype or commercially available product to a DoD contract[12]. For the commercial sector, "valley of death" refers to the time between product development and consumer marketing."[13]

Valuation[14] - Valuation is the analytical process of determining the current (or projected) worth of an asset or a company. There are many techniques used for doing a valuation. An analyst placing a value on a company looks at the business's management, the composition of its capital structure, the prospect of future earnings, and the market value of its assets, among other metrics.

Venture Capital[15] - Venture capital is a form of private equity and a type of financing that investors provide to start-up companies and small businesses that are believed to have long-term growth potential. Venture capital generally comes from well-off investors, investment banks, and any other financial institutions. However, it does not always take a monetary form; it can also be provided in the form of technical or managerial expertise. Venture capital is typically allocated to small companies with exceptional growth potential, or to companies that have grown quickly and appear poised to continue to expand.

Venture Debt[16] - Venture debt is a type of debt financing obtained by early-stage companies and start-ups. This type of debt financing is typically used as a complementary method to equity

venture financing. Venture debt can be provided by both banks specializing in venture lending and non-bank lenders.

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[1] "Dilution Definition," Investopedia, accessed May 12, 2022, https://www.investopedia.com/terms/d/dilution.asp.
[2] "Financial Technology – FintechDefinition," Investopedia, accessed May 12, 2022, https://www.investopedia.com/terms/f/fintech.asp.
[3] "Independent Research and Development," accessed May 12, 2022, https://www.ndia.org/policy/acquisition-reform/independent-research-and-development.
[4] "Business Ecosystem," Investopedia, accessed May 12, 2022, https://www.investopedia.com/terms/b/business-ecosystem.asp.
[5] "Loan Guarantee," in *Wikipedia*, October 19, 2021, https://en.wikipedia.org/w/index.php?title=Loan_guarantee&oldid=1050742541.
[6] "Program Element (PE)," AcqNotes, accessed May 19, 2022, https://acqnotes.com/acqnote/acquisitions/program-element-pe.
[7] "Risk Capital," Investopedia, accessed May 12, 2022, https://www.investopedia.com/terms/r/riskcapital.asp.
[8] "About | SBIR.Gov," accessed May 12, 2022, https://www.sbir.gov/about.
[9] "What Is a Startup?," Investopedia, accessed May 12, 2022, https://www.investopedia.com/terms/s/startup.asp.
[10] Irene Tzinis, "Technology Readiness Level," NASA (Brian Dunbar, May 6, 2015), http://www.nasa.gov/directorates/heo/scan/engineering/technology/technology_readiness_level.
[11] "What Is a Unicorn in Business?," Investopedia, accessed May 12, 2022, https://www.investopedia.com/terms/u/unicorn.asp.
[12] "DAU News - Through DoD's Valley of Death," accessed May 12, 2022, https://www.dau.edu:443/library/defense-atl/blog?TermStoreId=dce24bd1-67d5-449a-a845-034b26f02d5e&TermSetId=8f7816db-bdf4-4718-9235-765b669106cc&TermId=14ebb14e-a7d6-4156-8c1d-baac16c70f63&UrlSuffix=Valley-of-Death.
[13] Eric Lofgren, "The 'Valley of Death' and the PPBS in Defense Technology Transition," *Acquisition Talk* (blog), November 4, 2018, https://acquisitiontalk.com/2018/11/the-valley-of-death-and-the-ppbs-in-defense-technology-transition/.
[14] "How the Valuation Process Works," Investopedia, accessed May 12, 2022, https://www.investopedia.com/terms/v/valuation.asp.
[15] "What Is Venture Capital?," Investopedia, accessed May 12, 2022, https://www.investopedia.com/terms/v/venturecapital.asp.
[16] "Venture Debt," Corporate Finance Institute, accessed May 12, 2022, https://corporatefinanceinstitute.com/resources/knowledge/finance/venture-debt/.

Appendix C: Defense Acquisition and Industrial Base Background

Since the "Last Supper*"* in 1993, where Defense Secretary William Perry explained the fiscal realities of a shrinking defense budget, defense industry consolidation has been rampant.[1] The number of prime contractors has continued to decrease year-over-year for the past three decades, drastically reducing DoD market competition.[2] The few remaining prime contractors have entrenched the *iron triangle* to shape defense acquisition less focused on innovative consumption and more on large, long-lasting program procurement and sustainment.[3] For example, the average age of an aircraft in the U.S. Air Force fleet is thirty-one years old, yet the Service expends tens of billions of dollars on weapon system sustainment to keep them flying.[4] These sustainment costs are contracted back to the prime contractors. Defense industry consolidation has diminished competition, creating a moat around defense primes, with market barriers to entry in the form of bureaucratic entrenchment.[5] These factors have squelched new market entrants and their financers from gaining market share and industry traction.

In the 25 years since *The Last Supper*, the only large-scale company innovation success stories, or examples of defense industrial base expansion, have been Palantir and Space X. Both companies were founded and financed personally by billionaires and did not depend on private financing networks. Furthermore, Space X could only compete with the defense-created prime of United Launch Alliance (ULA) after filing an extensive and expensive lawsuit and receiving exclusive development funding from NASA.[6] The uniqueness of these cases highlights the reality that thousands of companies struggle to find follow-on opportunities after receiving initial early DoD funding, and 80% of new entrants to the defense market exit before receiving long-term contracts. This data supports the argument that the DoD needs to take a more proactive

effort to foster a broad pool of successful innovative founders participating in a robust, well-developed defense innovation ecosystem.[7]

Tangential to prime contractor consolidation and trends in defense acquisition has been the squeezing of program requirements over the years. The DoD's Joint Requirements Oversight Council (JROC) has offset fiscal tightening across the Department by over detailing the requirements process, often shoehorning concepts into narrowed capabilities to minimize the risk of scarce public funding.[8] Subsequently, neither the requirements nor acquisition processes deliberately incentivize prime defense contractors to innovate, causing a downward trajectory of defense industry IR&D.[9]

Furthermore, the Major Defense Acquisition Programs through the traditional prime contractor base take 6.9 years to develop new capabilities, and this is after a nearly two-year requirement and funding allocation process.[10] The length of these processes does not lend itself to incorporating new systems or disruptive technologies. Thus, the significant amount of traditional DoD resourcing is not advancing asymmetric capability but rather driving iterative improvements across capabilities and platforms that have existed for over a decade.

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[1] Aaron Mehta, "30 Years: William Perry — Reshaping the Industry," Defense News, October 25, 2016, https://www.defensenews.com/30th-annivesary/2016/10/25/30-years-william-perry-reshaping-the-industry/.
[2] "State-of-Competition-Within-the-Defense-Industrial-Base," n.d., 4–6.; "Endless Supper: Trends in Defense Mergers & Acquisitions," accessed May 3, 2022, https://www.defense-aerospace.com/articles-view/feature/5/217942/%3Ci%3E%28open%29%3C%C2%A7i%3E-an-%27endless-supper%27-for-defense-m%26a%3F.html.
[3] "State-of-Competition-Within-the-Defense-Industrial-Base," U.S. Department of Defense, Office of the Under Secretary of Defense for Acquisition and Sustainment, February 2022, n.d., 2–3, https://media.defense.gov/2022/Feb/15/2002939087/-1/-1/1/STATE-OF-COMPETITION-WITHIN-THE-DEFENSE-INDUSTRIAL-BASE.PDF.; "State-of-Competition-Within-the-Defense-Industrial-Base," 16–17.; Nathan Strout, "How the Air Force Plans to Find 'Defense Unicorns,'" C4ISRNet, November 7, 2019, https://www.c4isrnet.com/battlefield-tech/space/2019/11/07/how-the-air-force-plans-to-find-defense-unicorns/.
[4] "U.S. Air Force," The Heritage Foundation, accessed May 4, 2022, https://www.heritage.org/military-strength/assessment-us-military-power/us-air-force.; "AFMC Successfully Navigates FY20 Challenges," Air Force, accessed May 4, 2022, https://www.af.mil/News/Article-Display/Article/2387284/afmc-successfully-navigates-fy20-challenges/.
[5] "State-of-Competition-Within-the-Defense-Industrial-Base," 16–17.; Strout, "How the Air Force Plans to Find 'Defense Unicorns.'"

[6] "SpaceX Is Suing the Government — and Blue Origin and ULA Want to Intervene - The Verge," accessed May 18, 2022, https://www.theverge.com/2019/5/22/18635731/blue-origin-ula-spacex-lawsuit-us-government-air-force-awards.
[7] "State-of-Competition-Within-the-Defense-Industrial-Base," 10.; Reuters, "Pentagon Seeks to Boost Competition in Shrinking Defense Contractor Base," *Reuters*, February 15, 2022, sec. United States, https://www.reuters.com/world/us/pentagon-seeks-boost-competition-shrinking-defense-contractor-base-2022-02-15/.
[8] Pete Modigliani, Dan Ward, Tyler Lewis, and Wayne McGee. *Modernizing DoD Requirements: Enabling Speed, Agility, And Innovation*, 19-03715-2, MITRE Center for Technology and National Security, March 2020.; "Failures of Imagination: The Military's Biggest Acquisition Challenge," War on the Rocks, April 3, 2018, https://warontherocks.com/2018/04/failures-of-imagination-the-militarys-biggest-acquisition-challenge/.
[9] Pete Modigliani, Dan Ward, Tyler Lewis, and Wayne McGee. *Modernizing DoD Requirements: Enabling Speed, Agility, And Innovation*, 19-03715-2, MITRE Center for Technology and National Security, March 2020.; "Failures of Imagination: The Military's Biggest Acquisition Challenge," War on the Rocks, April 3, 2018, https://warontherocks.com/2018/04/failures-of-imagination-the-militarys-biggest-acquisition-challenge/.
[10] "Cycle Times and Cycles of Acquisition Reform," 7, accessed December 24, 2021, https://www.csis.org/analysis/cycle-times-and-cycles-acquisition-reform.

Appendix D: Financial and Innovation Clusters

Financial Clusters in the U.S.

Within the financial industry, the largest cluster of financial services resides in New York City. US and international commercial and consumer banks make their home here, along with the New York Stock Exchange and associated brokers, Bloomberg, insurers, and a branch of the Federal Reserve. The financial infrastructure that facilitates trillions of dollars in trade and transfers also resides in New York. Wealth management firms, private equity investors and, increasingly, VC establish offices here to be in proximity to the financial hub of the world and the suppliers of capital. While New York City and the surrounding region account for the largest financial cluster in the world, investors here generally look for investment opportunities elsewhere in the country.[1] Those seeking high returns from innovative start-ups first look to innovation clusters such as Silicon Valley, New York, and Boston.

Innovation Clusters in the U.S.

Entrepreneurs and innovation thrive when surrounded by supporting infrastructure, including academic and research institutions, related companies or industries, financial services, and state/local government or community supporting organizations. Start-ups also benefit from access to customer markets to support design and all stages of product development. The interplay between end users/potential customers and innovators can also facilitate the identification of additional use cases. Ideally, entrepreneurs have easy access to the full innovation finance stack, but seed funding and early-to-mid-VC often provide the financing most critical to the success of a start-up. While some seed and venture funding has moved online and even adapted crowd-funding models, the benefits of personal contact and co-location in the fate of early start ups cannot be understated.

Silicon Valley: Silicon Valley in California is known as the center of American innovation for good reason. In the first decade of this century, Silicon Valley and San Francisco startups, researchers, and entrepreneurs received over 143,000 patents, far exceeding any other city or region in the United States.[2] With the presence of successful former start-ups and ventures the likes of Google, Meta, and Apple, Silicon Valley is overflowing with capital and technology companies vying for the chance to become the next "unicorn." Silicon Valley largely remains focused on technology and software as a service, even in venture investments. This focus is due in large part to the lower capital requirements necessary to generate tenfold or even hundredfold multiple returns on equity. The markets for software as a service and other technology developments are also vast and startups that can make their product "sticky" enough to weather multiple sales cycles stand to grow long-term revenue sufficient to increase valuations and create attractive exit opportunities. Despite Silicon Valley's commercial focus, members of the ecosystem there are increasingly interested in developing technology to support US national security aims. The Silicon Valley Defense Group, established in 2015, aims to stoke interest in national security, with the goal of aligning and connecting, "the people, capital, and ideas that will ensure allied democracies retain a durable techno-security advantage."[3]

Boston: Greater Boston is considered one of the most innovative areas in the world, with the U.S. Chambers of Commerce ranking Boston as the number one city in the United States for innovation in 2016 and 2017.[4] A robust ecosystem of high-quality academic institutions including Harvard and MIT, entrepreneurial talent, supportive state and local governments, non-profits, and VC working together has boosted expertise across a number of sectors, including financial services, life sciences, and high technology industries like biotech, advanced manufacturing, and robotics. State and local government and non-profit organizations are

focused on serving as enablers for getting new businesses and ideas off the ground, motivated by the creation of both revenue and jobs within the jurisdiction and across the region. Boston's innovation ecosystem benefits from the collocation of dynamic individuals in related fields working toward moving new ideas from research to commercial and defense markets.

Washington DC: The success of commercial ventures and VC investments has given rise to a new breed of venture capitalists focused on U.S. national security. Defense and competition-minded investors based in DC are networking with innovation clusters across the U.S., including Silicon Valley, New York, and Boston, to develop the next generation of security technology innovations. This interest, combined with the complicated labyrinth of DoD acquisition policies and processes have given rise to a new business model of national security innovation concierge services. These services, including companies and initiatives like dCode and the Defense Entrepreneurs Forum were formed to help start-ups navigate federal contract opportunities and government markets. These enterprises were largely created due to an identified disconnect between industry/venture and DoD acquisition and contracting.
While the innovators do not necessarily reside in DC, the end users and arbiters of contracts do. DC-based government personnel often lack ties to innovation ecosystems, such as those described above. Building bridges between the nation's capital and innovation hubs is critical to accelerating DOD adaptation of new technologies. DOD leaders that are tied into the innovation ecosystem are more likely to develop requirements attuned to high technology commercial capabilities, a model that SOCOM has long applied to gain the best available capabilities for its warfighters, albeit on a smaller, specialized scale.

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[1] "Finance Industry - International Business," accessed May 5, 2022, https://www1.nyc.gov/site/internationalbusiness/industries/finance-industry.page.
[2] Lydia Belanger, "The Most Innovative Cities In America," Inc., April 2014, https://www.inc.com/magazine/201404/lydia-belanger/the-most-innovative-cities.html.

[3] Silicon Valley Defense Group, "About SVDG," Silicon Valley Defense Group, 2022, https://www.siliconvalleydefense.org/about-2.
[4] "Innovation that Matters," U.S. Chamber of Commerce, https://www.1776.vc/reports/innovation-that-matters-2017/.

Appendix D: Market Structures, Conduct and Performance (SCP) Analysis of Financing for Innovation Sources: Risk Capital and Banks

Risk Capital

In addition to the genius, entrepreneurial spirit, and initiative that elevates every innovative start-up, investment capital is the lifeblood that enables a company to grow beyond the founder's initial idea. Additionally, most start-ups must endure a lengthy time horizon until a sustaining revenue stream is established. Investment capital takes different forms, including angel investors, venture capital (VC), corporate venture capital (CVC), and private equity (PE).

Angel Investors

Entrepreneurs need cash early on to pursue their innovative ideas, so they initially turn to family and friends for financial help. They also seek seed money from wealthy individuals known as angel investors, who usually provide between $25 to $100 thousand in exchange for a small equity stake in the business.[1] Additionally, these investors might also require a board seat and serve as consultants to assist founders based on their desired involvement.[2] Finally, some angel investors might decide to financially carry a company until the founders can secure venture capital funding.[3]

Venture Capital (VC)

VC is one of three types of private equity. Investors pool financing for start-ups and small businesses with long-term growth potential. Investors often seek a return of 10-times their investment after corporate valuation but are often seeking the next unicorn with a $1 billion-plus valuation. Here, investors typically take a share of corporate equity, play an active role in corporate management, and plan to exit the firm in less than six years.[4] There is tremendous competition in the commercial sector for high payout deals, which often results in little to no time to perform the in-depth due diligence on investments, thereby increasing investment risk.

Unfortunately, available investment capital was impacted by the 2008 financial crisis when investors faced low interest rates.[5] However, capital availability might change depending on the potential impact of looming disruptions in the economic environment stemming from increased inflation and higher interest rates. Compounding this concern is the potential for a recession that typically weakens stock market performance.

As investment behavior changes across the VC industry, so will the already limited capital available for investment in the defense industry. The complex and laborious regulatory environment already obstructs participation and results in a long time horizon to realize investor returns. For instance, a company could wait years before receiving a contract that provides a "sticky" defense revenue stream. This subsequently forces entrepreneurs and investors to focus on the commercial sector over the defense. Therefore, fewer investors are likely to tolerate the long wait for returns in the defense sector in an economic downturn.

Corporate Venture Capital (CVC)

In addition to the above sources of private capital, corporations also provide VC with the sole goal of gaining a competitive advantage. There are two types of CVCs: strategically driven and financially driven. Financially driven CVCs invest for leverage, while strategically driven CVCs invest to increase sales and profits by making deals with start-ups that use new technologies.[6] CVCs also serve as a gateway for the possible acquisition of smaller, innovative start-ups while enabling them to maintain positions as market leaders. One example of this dynamic is Snapchat and Instagram, which are now owned by Facebook.[7]

Recently, defense prime contractors like Boeing, Lockheed Martin, and Raytheon are learning from the traditional VCs and forming their own CVC organizations to capitalize on this growing market. These defense giants are leaning forward to attract up-and-coming tech start-

ups and help them maneuver through the complicated defense regulatory process. Obviously, CVCs also use the opportunity to help their parent company garner competitive advantages and new profits.

Private Equity (PE)

PE generally refers to equity investments in exchange for ownership shares in a firm that has not gone public yet.[8] PE funds can be pooled from high-net-worth individuals, institutions, or firms. While VC typically invests in early-stage start-ups, PE investors focus on more established private firms. They may also evaluate them for merger or acquisition potential. PE investors may also consider public firms for a potential buyout, purchasing a mature public company and taking it private.[9] A start-up is generally inappropriate for growth equity or buyout because each requires an established history of financial performance.[10] Most PE firms focus on more mature companies with an established business model.

Structure-Conduct-Performance Analysis

Structure: Sources of investment capital range from individual investors known as angel investors, pooled funds from groups of investors (limited partners), corporate funding in the form of corporate VC (CVC), and money from federal agencies obligated through an assortment of targeted programs, such the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (SBTT) programs. Each type of investment seeks a targeted return based on a broader risk strategy, is applied at different stages of a start-up's life, and remains active throughout a company's lifecycle.

The market for each type of capital is mainly divided based on a company's development phase. The start-up phase attracts money from angel investors and venture capitalists when the risk and reward potential is highest. Mid-phase and fully mature companies receive capital from

private equity firms focused on growth and buyout opportunities, where due diligence and market analysis can be thorough. Mature companies can also be a target for hedge funds pursuing corporate stocks.

Conduct: Each of the sources of capital behaves differently based on its target market. Angel investors accept significant risk while focusing on companies in the early stages of existence. These investors hope the company achieves early success and returns their investment at high multiples in a short timeframe. On the other hand, VCs tend to focus on specific industries with which it has familiarity. For CVC, these investors typically focus on industries related to the parent corporation. Both VC and CVC pursue a medium time horizon, which for start-ups has spanned at least six years since 2007.[11]

Performance: Angel investing is high risk because the initial investment might not be made back based on an early concept. Funding is typically provided to further develop and refine the product. However, the effective internal rate of return for a successful angel investor portfolio is approximately 22%.[12] This may appear to be high, but banks are often not an option at this point of development for start-ups. Therefore, an angel investor's primary role is to assist start-ups in making it to the initial stages of revenue production.

Moving to VC, these investors seek high returns in terms of subsequent corporate valuations. They often look for the next big hit (unicorn) like Google or Apple. However, few start-ups ever achieve this unicorn status which makes the expectation of substantial profitability meager. For example, the probability of a VC funding a start-up is 0.7%; the odds of a funded company achieving financial success are 8%, and the total odds of success are 0.05% (1 in 2,000).[13] Shikhar Ghosh, a senior lecturer at Harvard Business School, claims that up to 75% of venture-backed start-ups never return cash to their investors, and 30% to 40% of those liquidate

all assets.[14] According to the National Venture Capital Association (NVCA), CVC investments account for 45% of total VC investment in 2019, up from only 10% in the early 2000s.[15] The next source of capital comes from banks.

Banks

The United States has the largest and most liquid financial markets globally, with the finance and insurance market alone representing 7.5% of the nation's gross domestic product in 2018.[16] This market comprises companies and individuals that provide securities, banking, insurance, foreign exchange, and investment services. The banking sector plays a critical role in maintaining the nation's economic prosperity. Specifically, banks are the primary credit supplier, ranging from loans to individuals to buy vehicles and homes to loans to businesses to purchase facilities and make payrolls.

There are several types of banks operating in this sector: retail, commercial, investment, credit unions, private, savings and loan associations, shadow, neo banks, and challenger. However, the following will describe the two most significant and most applicable to financing innovation; commercial and investment banks. Additionally, commercial and investment banks have the longest history. In 1933, Congress enacted the Glass-Steagall Act to avoid another banking collapse which forced banks into two separate business entities, securities banking and commercial banking[17]. Security banks managed the investment business, and commercial banks offered financial services to businesses and consumers.

Commercial Banks

Commercial Banks offer financial services to businesses while ensuring economic stability and the sustainable growth of a country's economy. Its focus is on products and services specifically designed for companies, such as deposit accounts, lines of credit, merchant services, payment processing, commercial loans, global trade services, treasury services, and other

business-oriented offerings. Business segments typically include loan, credit, auditing, trust, consumer banking, and business. Examples of commercial banks include JPMorgan Chase, Wells Fargo, Citigroup, Bank of America, Goldman Sachs, U.S. Bankcorp, PNC, and Truist.

Investment Banks

Investment banks mediate large and complex financial transactions between investors and corporations. Business segments typically include underwriting, M&A, sales and trading, equity research, and asset management. Examples of global investment banks include JPMorgan Chase, Goldman Sachs, Morgan Stanley, Citigroup, Bank of America, Credit Suisse, and Deutsche Bank.

Structure-Conduct-Performance Analysis

Structure: Market structure consists of the stable features of the market environment that influence the rivalry among the buyers and sellers operating within it. The U.S. banking sector's market structure is essentially monopolistic competition. It is characterized by the coexistence of a few large dominant banks and many smaller banks. The market also consists of many buyers and sellers. It has small but real barriers to entry (highly regulated, technology, and brand strength) and differentiated products. The U.S. has over 5,000 banks (sellers) with over 131.3 potential customers (buyers), 124.2 million banked, and 7.1 million unbanked.[18] Market entry is relatively simple, although it is regulated by the government and dominated by brand strength. The major players in this sector are JPMorgan Chase, Bank of America, Citigroup, Wells Fargo, and U.S. Bancorp. Although there are many smaller banks, these top five dominate the sector with almost $9 trillion in total assets combined.[19]

Conduct: Firms choose their own strategic behavior, investment in research and development, advertising levels, collusions, etc. Banks (sellers) make money by providing

services to customers (buyers). These services include accepting deposits, advancing loans, credit creation, trading securities for cash or other securities, and promoting securities. Banks also serve as enablers to VC by providing financial transaction advisory services, such as payroll, and debt financing. Bank growth is heavily reliant on mergers and acquisitions, which is critical to competing with new competitors such as fintech and cryptocurrencies disrupting the sector.

The crypto ecosystem offers opportunities and challenges. Risks to the banking system can arise from substitution offering anonymity or significant data gaps in financial integrity. The advent of crypto assets and stablecoins in emerging markets and developing economies may accelerate dollarization risks.[20]

As for fintech, global funding reached a record $132 billion in 2021, more than twice the 2020 mark and accounting for 21% of all venture dollars.[21] The advancement of fintech applications in the global banking system disrupts how the traditional banking industry functions. One exciting aspect of fintech is artificial intelligence or A.I. The use of A.I. will affect how financial institutions de-risk banking in the future and how vulnerable the system's integrity is to new and unknown A.I. algorithm threats.[22]

Performance: The banking sector is healthier now than before and after the financial crisis of 2008, primarily due to increased government regulations and stress testing. In 2020, bank assets globally amounted to more than $180 trillion (USD), up from $155.4 trillion (USD) in 2019.[23] The most widespread trend is the shift to digital, which includes mobile, online banking, robo-advisors, AI, and robotic process automation. The evolution of digitalization benefits the banking industry. However, it has also produced fierce competitors from fintech start-ups and the consolidation of smaller banks and start-ups.

Additionally, banks are the executors of the E in DIME (diplomacy, information, military, and economics). Geo-political tension continues to affect the banking industry through

the employment of sanctions. Here, banks form the nation's frontline for implementing sanctions where authorized. The Russia-Ukraine conflict is the most recent example that will set the stage for multi-national banks to enable multi-lateral sanctions. Banks must now factor in the significance of this requirement in business modeling as future scenarios may include other larger nation-states. This risk becomes very disruptive to affected banking customers and risks increasing the popularity of offset currencies like crypto.

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[1] Richard Harroch, "What Angel Investors Want To Know Before Investing in Your Startup," Forbes, December 13, 2020. https://www.forbes.com/sites/allbusiness/2020/12/13/what-angel-investors-want-to-know-before-investing-in-your-startup/?sh=5de43db41a11.

[2] Murray Newlands, "Pros and Cons of Using an Angel Investor to Fund a Startup," https://www.startupgrind.com/blog/pros-and-cons-of-using-an-angel-investor-to-fund-a-startup/.

[3] Dave Brkus and JD Davids, "The Valley of Death for Statips." Smartmoney Startups, October 18, 2017, https://www.smartmoneystartups.com/the-valley-of-death-for-startups-dave-berkus/.

[4] Narbe Alexandrian, "Unreaveling the venture capital timeline," RIV Capital, November 23, 2020, https://www.rivcapital.com/the-deep-end/blog-details/the-deep-end/2020/11/23/unravelling-the-venture-capital-timeline.

[5] Gene Teare, "Lessons From 20028: How The Downturn Impacted Funding Two To Four Years Out," Crunchbase, March 24, 2020, https://news.crunchbase.com/news/lessons-from-2008-how-the-downturn-impacted-funding-two-to-four-years-out/.

[6] Corporate Finance Institute (CFI), "Corporate Venturing – Directly investing corporate funds into external startup companies," https://corporatefinanceinstitute.com/resources/knowledge/finance/corporate-venturing-corporate-venture-capital/..

[7] Corporate Finance Institute (CFI), "Corporate Venturing – Directly investing corporate funds into external startup companies, https://corporatefinanceinstitute.com/resources/knowledge/finance/corporate-venturing-corporate-venture-capital/.

[8] "Private Equity vs. Venture Capital: What's the Difference?," Investopedia, accessed May 18, 2022, https://www.investopedia.com/ask/answers/020415/what-difference-between-private-equity-and-venture-capital.asp.

[9] Catherine Cote, "3 Key Types of Private Equity Strategies," Harvard Business School Online, July 13, 2021, https://online.hbs.edu/blog/post/types-of-private-equity.

[10] Catherine Cote, "3 Key Types of Private Equity Strategies," Harvard Business School Online, July 13, 2021, https://online.hbs.edu/blog/post/types-of-private-equity.

[11] Narbe Alexandrian, "Unreaveling the venture capital timeline," RIV Capital, November 23, 2020, https://www.rivcapital.com/the-deep-end/blog-details/the-deep-end/2020/11/23/unravelling-the-venture-capital-timeline.

[12] Akhilesh Ganti, Angel Investor, Investopedia, March 22, 2022, https://www.investopedia.com/terms/a/angelinvestor.asp.

[13] Corporate Finance Institute (CFI), How VSs Look at Startups and Founders, https://corporatefinanceinstitute.com/resources/knowledge/other/how-vcs-look-at-startups-and-founders/
[14] Wendi Jarchow, "The Venture Capital Success Rates for Startups, " RiverSaaS Capital, https://www.riversaascapital.com/the-venture-capital-success-rate-for-startups/.
[15] Xuan Tian and Kailei Ye, "A Dark Side of Corporate Venture Capital," August 2020, https://www.aeaweb.org/conference/2021/preliminary/paper/iNeGYkzz.
[16] Expert Market Research. United States Financial Services Market Outlook. Accessed May 2, 2022. https://www.expertmarketresearch.com/reports/us-financial-services-market.
[17] Julia Maues, *"Banking Act of 1933 - Glass Steagall Act,"* Federal Reserve History; Nov, 22, 2013, accessed 01 May 2022, Banking Act of 1933 (Glass-Steagall) | Federal Reserve History
[18] *Megan Leonhardt "7.1 million American households didn't have a bank account last year-the lowest rate since 2009," CNBC.Com*, October 19,2020, 2021, accessed 05 May 2022, 7.1 million American households didn't have a bank account last year (cnbc.com).
[19]Alicia Phaneuf. Top 10 Biggest US Banks by Assets in 2022. Insider Intelligence, January 02, 2022, accessed May 4, 2022, https://www.insiderintelligence.com/insights/largest-banks-us-list/.
[20] Global Financial Stability Report 2021, IMF, October 2021. Chapter 2 – The Crypto Ecosystem and Financial Stability Challenges (Pp 41-55) https://www.imf.org/en/Publications/GFSR/Issues/2021/10/12/global-financial-stability-report-october-2021?utm_medium=email&utm_source=govdelivery.
[21] CBinsights, "State of FINTECH," Global Report, 2021, January 25, 2022, accessed May 4, 2022, https://www.cbinsights.com/research/report/fintech-trends-2021/.
[22] R, Jesse McWaters *"Navigating Unchartered Waters - A roadmap to responsible innovation with AI in financial services,"* World Economic Forum, 2020, accessed May 4, 2022, https://www3.weforum.org/docs/WEF_Navigating_Uncharted_Waters_Report.pdf.

[23] F. Norrestad. Total assets of banks worldwide from 2002 to 2020. Statista, December 21, 2021, accessed May 4, 2022, https://www.statista.com/statistics/421215/banks-assets-globally/.

Appendix F: Lines of Effort Analysis: U.S. - Russia - China

Lines of Effort Analysis Model Explained

The Lines of Effort (LOE) model introduced by the Eisenhower School Industry Study faculty provides a comparative analysis across different drivers of activity.[1] We use the LOE model to compare the financing structures of the United States, China, and Russia that support innovation in areas affecting national security. For the United States, we analyze those providing financial services to those supplying innovative products to the DoD. Russia and China combine public and private enterprise to provide similar financing functions, which necessitates expanding LOE analysis to include their respective financing options. This LOE analysis attempts to compare the activities of a wide variety of financial services across three distinct national finance systems, from small-scale angel investors to the largest private equity firms and from government funding to investment bank services. The segmented nature of the LOE model makes such a comparison possible and generates useful insights.

The LOE model starts by identifying the primary drivers of the activity under analysis. The drivers are then broken down into specific parameters which influence the effect of the driver. Scores for each parameter follow a low-medium-high ordinal scoring system using a red-yellow-green color coding that follows the same order. The scoring for each country relies on the Industry Study's collective meetings and research. Admittedly, that scoring is subjective, but the model identifies various strengths and weaknesses using the same baseline, allowing for comparisons between the three countries.

Drivers and Parameters

The three drivers of this LoE model conform to the main themes of the Industry Study paper: creating a financing system that is relevant, complementary, and agile to support the DoD Innovation Network.

The first driver assesses the relevance of the financing of national security innovation to the rapid technology transitions of the 21st century. As the Fourth Industrial Revolution advances, all elements of innovation ecosystems, including financing, must keep pace.[2] This driver measures the ability of each nation's financing tools to support the quicker pace and broader scope of innovation financing. Three parameters, national in scope, define this driver. The first parameter is public funding availability, measuring how government funding mechanisms allow public sector disbursement of financial resources. Second is a measurement of the security of rights to intellectual property (IP). This assesses the level of protection (legal and cultural) for IP, measuring the country's induced profit motivation for developing innovative products. The third parameter of this driver scores the networks of innovators and financiers for national security innovation by considering the level of access and communication between those needing financing and those providing capital.

The second driver looks at the structure of the existing private financial markets and their ability to enhance the financing of national security innovation. The four parameters of this driver are also national in scope. The first parameter is a measure of the nation's access to capital. This determines if institutional investors and other first-tier capital suppliers provide the financial foundation to generate innovation. The second parameter looks at the breadth of the national pool of innovators, determining if there is a 'customer' base seeking capital and if it is sufficient in size and profit potential to positively influence the financiers' risk-reward calculations. The

third parameter looks at the nation's security and surety of investments. This broadly measures the legal protective framework to obtain investment profits, determining if financiers are guaranteed market access and equal information sharing. The final parameter measures financial technology improvements for each nation’s financing industry. This evaluates the efficiency of the process to implement technology enhancement in the investment process and thus generate greater 'productivity' in financial services.

The third driver looks at the agility of the innovation financing system within each nation. This concentrates on the ability of the national security innovation ecosystem to pull in the necessary private enterprise financing by conforming to or operating within the market demands of the private sector. This driver is composed of three parameters, specific to the national security system of each country. The first parameter looks to see if the expected profit timeline matches the expectations of the financiers. The second parameter measures the product's market potential, specifically within the national security sphere. This asks if there is a "light at the end of the tunnel" for investors, with the defense market signaling confidence (determined by anticipated actual purchases by the national security apparatus of each nation) that their investments will remain profitable. The final parameter looks at the synergy of financial methods to determine if the different investment vehicles interact so that 'hand-offs' can occur to protect earlier investors.

Lines of Effort Scoring by Country (U.S., Russia, and China)

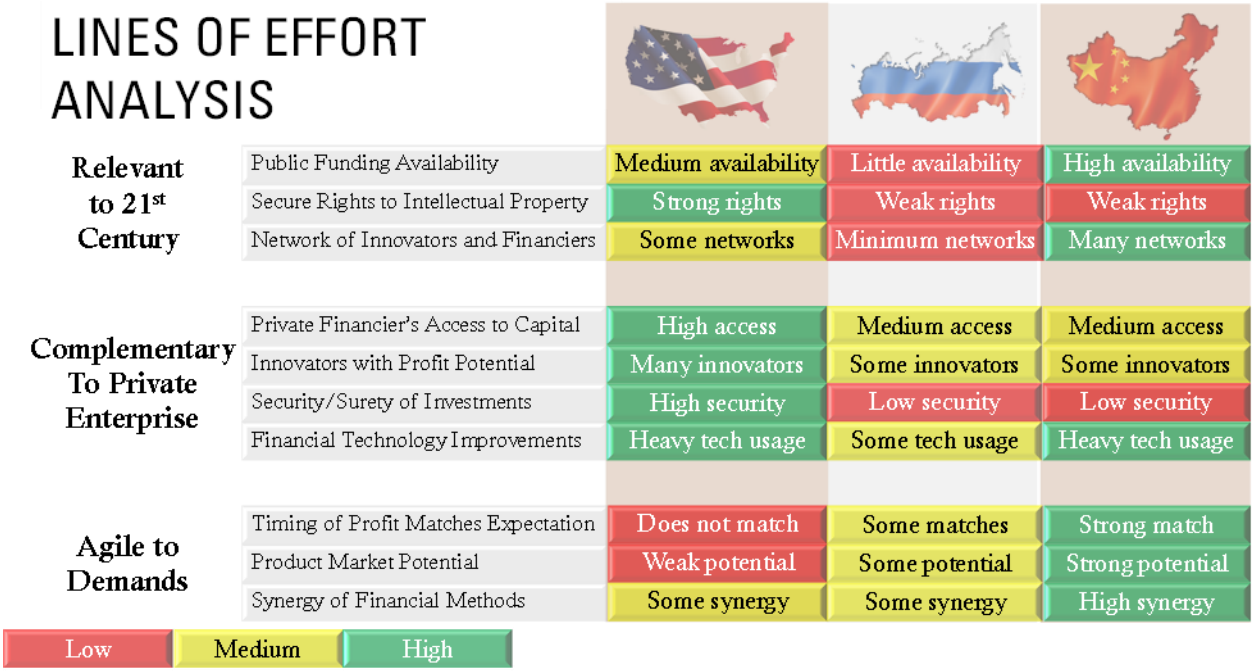

Figure 1: Lines of Effort Comparison

U.S.

The scoring for the U.S. within the LOE model highlights the unique attributes of America's financial system and the inability of the nation's security innovation ecosystem to fully harness the advantages of that uniqueness.

Public funding availability gets a medium score. The U.S. government offers multiple paths for receiving public funds, but the bureaucracy is problematic and sometimes detrimental to business efforts, especially limiting to small start-ups with the most innovative energy.[3] There is a high score for securing rights to intellectual property as the U.S. protects patents, securing innovation investments from exploitation by the government and other actors.[4] A score of medium goes to the networking of innovators and financiers. The U.S. ecosystem has strong networking potential for innovators and financiers. But DoD does not have a strong presence of empowered actors while DoD products are not part of many networks. However, the creation of

the Defense Innovation Unit and the service accelerators has better tied DoD into these networks.[5]

As access to capital in America is not really an issue, the private financier's access scores a high. America's civilian sector has a strong innovation pool with high-quality entrepreneurial talent in sufficient numbers to provide bountiful amounts of sweat capital, scoring a high for the nation's overall ability to supply innovators with profit potential. Considered safe and dependable, there is assurance that the U.S. government or other actors will not consume profits from investments, providing a high score for security and surety of assets. As a continued global leader of financial technology development, with many firms contributing to the ongoing financial industry disruption, the U.S. scores a high for financial technology improvements.

The parameter of profit timing matching expectations scores low as the DoD does not consistently offer investors a timely investment return. The varying built-in delays within DoD's acquisition processes, intended to protect public funds from adverse investments, conflict with private enterprise investment timelines. Product market potential receives a low score. Given security protocols and contracting requirements, the DoD limits detailed demand signals to a small cadre of established contractors and semi-public entities. Additionally, there is no sole source of consistent demand. It is dependent on multiple public sector actors and the rhythm of the DoD's acquisition processes. There is a disconnect between the demand signal (from requirements) and the vast pool of innovators and financiers looking for market potential. Given the nature of the complicated requirements and budgeting processes, even strong initial demand signals from senior leaders do not guarantee future investment returns.[6] Finally, the synergy of financial methods receives a medium score. The DoD does not operate in a fully optimized system of investment hand-offs. The higher-level investment capital is ready to support with

money, especially for businesses whose products achieve ‘stickiness’ with DoD contracts. But the wariness of lower-tier risk capital to invest in the initial stages of defense innovation reduces the synergy of the overall capital supplying stack.

Russia

Before the recent events in Ukraine, the Russian Federation was making progress in fostering its historically innovative science and technology workforce that drew domestic and international investments. Therefore, the following scoring represents a pre-conflict Russia with a functioning defense industrial base and a growing public/private-funded innovation ecosystem.

The score for public funding availability is low as government research and development (R&D) investment continues to lag compared to similar countries. For example, in 2019, Russia invested only 1.1% of total government revenue compared to 2.5% and higher of comparable countries.[7] Similarly, securing rights to intellectual property received a low score as the country continues to struggle with providing adequate legal protections and other regulatory controls. While companies and brand names receive some level of IP protection, other areas of IP like know-how and creative works do not always receive the same (i.e., software, databases, invention, and industrial designs).[8] Network of innovators and financiers also gets a low score as 80% of businesses in the defense/space, banking, transportation, and energy sectors are state-owned.[9] Unfortunately, this limits Russia's innovative capabilities inherent to its highly skilled and educated workforce.

Private financier’s access to capital earned a medium score because the funding is available, just not to the same scale as other developed countries. For example, venture capital investments in 2019 totaled more than $427 million compared to the tens of billions available in countries like the U.S. and China.[10] Innovators with profit potential also scored a medium as

Russia is known for producing skilled science and engineering talent, which was reflected in the 2021 Global Innovation Index that ranked the country 45th out of 132 economies.[11] Unfortunately, the financial infrastructure required to foster innovative growth and protect investments is lacking and remains prone to corruption, earning the security and surety of investments a low score.[12] Especially in light of recent events, this discourages further international investment in Russian start-ups and companies. The final parameter, financial technology improvements, scores a medium. Russia has a functioning banking sector that connects investors (domestic and international) with innovators, including its own cross-border payment system.[13]

For the final section, all parameters scored a medium due to the Russian government's significant influence and control over the economy and key industries (including banking).[14] This results in a "take it or leave it" profit mentality for investors and companies seeking to provide innovative products to government-dominated industries. Further, these non-government financiers and innovators must also compete for market share with large numbers of state-owned enterprises that receive federal funding and support.[15]

China

As the world's leading exporter of goods, People's Republic of China (PRC) has the second-largest economy globally, with over $17 trillion in gross domestic product.[16] The PRC also dominates manufacturing markets, as the country's cheap labor drew manufacturing jobs as firms outsourced to decrease costs over the last several decades.[17] The PRC's manufacturing expertise and economic growth translates to significant influence in the global economy and has allowed the PRC is leveraging its economy to finance innovation. Authors Graham Allison et al. stated, "President Xi Jinping declared technological innovation has become the main

battleground of the global playing field, and competition for tech dominance will grow unprecedentedly fierce."[18] China understands that advancements in technological innovation are critical for GPC globally.

For the first driver, China scores high for public funding availability. President Xi Jinping has a vision for China as a global power. In pursuit of their long-term strategy to become a superpower and achieve the great rejuvenation of China by 2049, the PRC and Chinese Communist Party (CCP) are increasing their economic and technological strength to become a global leader in innovation while completing its military modernization by 2035.[19] While the U.S. has distinct defense and commercial markets, the PRC blends its military and civilian innovation and R&D, applying a strategy of military-civil fusion (MCF). Under MCF, the CCP is "systematically reorganizing the Chinese science and technology enterprise to ensure that new innovations simultaneously advance economic and military development."[20] MCF favors military and national security uses of technology and CCP rights to IP, resulting China's low score for securing IP rights. The intrusive nature of MCF limits the ability of individual entrepreneurs to obtain profits outside the confines laid down by government policy. According to the Atlantic Council, "Beijing is widely observed – including by Chinese analysts – to increase state influence in innovation rather than reduce it, as measured by guidance funds, military-civil fusion, regulatory tightening, and planning programs."[21] Finally, China scores a high for government interaction with its network of innovators and financiers. The close collaboration of government, financing, and individual entrepreneurs has been a hallmark of China's productive innovation ecosystem. The PRC embraces disruptive innovation and maintains a higher risk tolerance to maximize speed and flexibility to integrate its defense industrial base, commercial, science, engineering, and innovative technology.

China's controlled market economy creates shortcomings in the country's broader private enterprise system. Though China has plenty of capital, favored industries and individual market initiatives see much more capital flow. Since access to capital can be limited by government policy, the PRC earns a medium score for private financier access to capital. China is rapidly rising as a global leader in innovation., but government restrictions result in a medium score for innovators with profit potential. Though plenty of good ideas float around China's innovation ecosystem, open market investment opportunities may be limited by government direction. The surety of investments in China scores low due to the same controlled nature of the economy. Still, the PRC and CCP understood the importance of China evolving, arguing that innovation investments are critical to China's future success and may mitigate aging population issues. According to the U.S.-China economic and security review commission report, "the CCP's Made in China 2025 plan is augmenting state support for emerging technologies and not only does innovation in these fields have great commercial potential, but Chinese policymakers also see it as instrumental in resolving key issues currently facing China's economy and society, from an aging population to environmental degradation (2021, 7).[22] This recognition of emerging technologies like fintech that supports the country's innovation ecosystem substantiates a high score for financial technology improvements. The CCP is accomplishing their long-term strategy and short-term initiatives to boost innovation and its economy.

Many of the traits that score China low for complementing the private enterprise become advantages when it comes to the government's ability to use the financial industry to harness innovative products. In 2021, China ranked #3 as an innovation economy in Asia; #1 upper-middle-income innovation economy; and earned a #12 overall global innovation ranking, a two-point improvement from 2020.[23] Thus, there appears to be close synchronicity to the timing

expectations of national security innovation financiers and government purchasers. This scores China a high for its timing of profit matching investor expectation. China is expanding its economy and attaining science and technology growth in defense and fintech. The OSD annual report to Congress found, “China is investing to acquire critical technologies that will be foundational for future innovations both for commercial and military applications, including A.I., robotics, autonomous vehicles, quantum information sciences, augmented and virtual reality, financial technology, and biotechnology.[24] PRC telegraphing of future requirements creates a strong, clear demand signal to investors, equating to high score for product market potential. Finally, the synergy of public and private financing facilitates transitions between early start-up investments and later stage investors in a government-managed innovation environment. China is second to the U.S. in start-up “unicorn” success in China, showcasing the PRC’s ability to transition innovation to commercial success, even in a controlled market.[25]

Lines of Effort Scoring Comparative Analysis Summary

Several themes emerge when looking at the U.S., China, and Russia in a comparative analysis. In the driver for relevance to the 21st Century environment of rapid technology transitions and adaptive financing, China's MCF has a clear advantage over the current U.S. systems. China makes public funding easy to access for innovations with national security potential, has constructed close formal ties between the innovators and their financiers, and has emphasized using commercial technology to advance its military and civilian fusion. The U.S. ranks behind China in these categories, although the level of difference varies considerably by topic area. In the U.S. public funding is available, but the process to access it is not always easy. The reward for a start-up may not be worth the cost (in time and energy). There are solid civilian networks of innovators and financiers in the U.S. These networks are more robust in many cases than China's. But only recently has the DoD made overt attempts to involve themselves in this network. While the DoD appears to lag in routine collaboration with the U.S. civilian sector, the Chinese national security apparatus is advancing technology to identify favorable investments. Moreover, the Russian Federation is behind the U.S. and China in financing innovation. Russia relies on its strong pool of pseudo-official defense organizations staffed by homegrown talent to attempt relevance, despite the 21st century's quick adaptation and transition needs.

The U.S. has a distinct advantage over China when considering the ability of national security innovation to complement private enterprise. As this factor strongly favors the nation with the most substantial civilian innovation sector, the U.S. coming out ahead is no surprise. America's wealth enables an ability to pool capital. The ubiquity of innovation generation of clusters and laws favoring surety for investments work together to place the U.S. ahead of the more controlled economies of China and Russia. However, the concern is China's macro-efforts

to fix this discrepancy. China fuses military and civilian innovation to grow its military capability and benefit its civilian advancements. There are echoes of America's jump-start of the information revolution using the government-funded research and development efforts of the early and middle Cold War era. The controlled economies of Russia and China can allocate resources for targeted innovation efforts, but this same control may deny the bounty of private investments. Attempting to control national market dynamics comes at a price.

The U.S. faces its most critical challenge in the agility driver, especially compared to China. The market dynamics of America's civilian sector come into direct contact with the functioning of DoD's requirements, budgeting, and acquisition systems. Investors are, understandably, leery to partner with U.S. national security procurement. The DoD has long timelines from initial contracts to at-scale purchases, many stakeholders determining final procurement (and thus private enterprise profit), and unstable requirements. The reasoning behind these three activities, intended to protect public funds and lower risk in strategic investments, runs against the free-market practices necessary for private enterprise profitability. Given China's ability to merge these practices within their civilian sector in their MCF construct, their pendulum shifts to a more controlled method of ensuring profitability within specific innovation pathways. With its generally closed system and close relation between defense industries and national agencies, Russia has an advantage, albeit without some innovation dynamics favorable to China. The U.S. possesses a healthy upper-tier financing system, including private equity and large investment banks supplying capital to mature business efforts. These provide the potential for synergy of financial efforts. But the unfavorable conditions for lower-tier investors degrade their participation in the DoD sphere, thus denying a 'hand-off' to the higher-end capital providers.

Collectively, this analysis points a path toward three improvements the U.S. needs to make to its national security innovation efforts, allowing the DoD to improve its participation in the financing for innovation sphere. First, the DoD needs to better cultivate its innovation ecosystem. Overcoming the inertia in many DoD processes to better optimize connections to private capital, accelerating access to more types of capital, and better leveraging of America's private capital strengths are essential to this cultivation. Second, the U.S. must build a bridge across the acquisition valley of death for those national security entrepreneurs embarking on DoD-focused innovation. This bridge will improve the agility and relevancy of the DoD's innovation financing efforts by realigning demand-side efforts to provide timely profit for previously non-DoD affiliated firms. Such changes require establishing more significant market-based incentives when DoD interacts with America's healthy private enterprise innovation pool. Finally, the U.S. must maintain its financing innovation advantage. This comes through continued enhancement of its human capital efforts through smarter access to America's innovation talent. This is accomplished through more comprehensive nationwide STEM-related edification, and a greater ability of the DoD to develop long-term relationships with foreign-born innovative talent working in the U.S. Maintaining an advantage also comes from continued support for financial technology advancement. Policies and activities that promote development of new financial practices must work alongside updated regulations that both protect investors but also allow financial services to continue experimentation of new financial services.

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[1] Tara Feret Erath, "Financing for Innovation Course - IS 21" (Course Slides, Eisenhower School, National Defense University, April 26, 2022).
[2] Thomas Philbeck and Nicholas Davis, "The Fourth Industrial Revolution: Shaping a New Era," *Journal of International Affairs* 72, no. 1 (2018): 17–22.
[3] Ben Van Roo, "Emerging Tech Is Transforming War in Real-Time, yet the Biggest DOD Incubator Is Stuck in the Past," Substack newsletter, *Leave It to BVR — Defense, AI, and Policy* (blog), May 4, 2022, https://benvanroo.substack.com/p/coming-soon.

[4] Stephen Ezell, "Comments to NIST on Rights to Federally Funded Inventions" (Washington, D.C.: Information Technology and Innovation Foundation, March 23, 2021), https://itif.org/publications/2021/03/23/comments-nist-rights-federally-funded-inventions.
[5] Pasha Moore et al., "From the Lab to the Battlefield: Maximizing Defense Innovation" (Panel, Reboot American Innovation, Washington, D.C., May 2, 2019), https://www.youtube.com/watch?v=--tPiXPtvFc; Shands Pickett, "Reboot the Defense Innovation Ecosystem," War on the Rocks, April 7, 2022, https://warontherocks.com/2022/04/reboot-the-defense-innovation-ecosystem/.
[6] Riya Patel, dCode Site Visit, In Person, April 21, 2022.
[7] "Russian Federation: Key Issues and Policies | READ Online," oecd-ilibrary.org, accessed April 29, 2022, https://read.oecd-ilibrary.org/industry-and-services/russian-federation-key-issues-and-policies_9789264232907-en.
[8] "Russian Federation."
[9] "Russian Federation."
[10] "Value of Venture Capital Investment in Russia 2020," Statista, accessed May 3, 2022, https://www.statista.com/statistics/1062075/venture-capital-amount-invested-in-russia/.
[11] Dutta Soumitra et al., *Global Innovation Index.* (Unknown), 163, accessed May 3, 2022, https://doi.org/10.34667/TIND.44315.
[12] "Russian Federation," 29.
[13] "China and Russia: Economic Unequals," accessed May 9, 2022, https://www.csis.org/analysis/china-and-russia-economic-unequals.
[14] "Russian Federation," 70.
[15] "Russia's Uphill Struggle with Innovation," Text/HTML, World Bank, accessed April 28, 2022, https://www.worldbank.org/en/news/opinion/2018/09/17/russias-uphill-struggle-with-innovation.
[16] China - Statistics & Facts, *Statista* (2022), https://www.statista.com.
[17] Prince Ghosh, "The Exodus Of Chinese Manufacturing: Shutting Down The World's Factory," *Forbes* (2020), 1–10, https://www.forbes.com/sites/princeghosh/2020/09/18/the-exodus-of-chinese-manufacturing-shutting-down-the-worlds-factory/?
[18] Graham Allison, Kevin Klyman, Karina Barbesino, and Hugo Yen, "The Great Tech Rivalry: China vs. the U.S.," *Belfer Center for Science and International Affairs*, 1–52, Harvard Kennedy School: Cambridge, MA, 2021. (2021, 3) https://www.belfercenter.org/publication/great-tech-rivalry-china-vs-us?
[19] Office of the Secretary of Defense (OSD), "Military and Security Developments involving the People's Republic of China 2020: Annual Report to Congress," *OSD* (2020), 1–200, https://www.defense.gov/News/Releases/Release/Article/2332126/dod-releases-2020-report-on-military-and-/.
[20] U.S. Department of State, "What-Is-MCF-One-Pager.Pdf," Military-Civil Fusion and the People's Republic of China, May 2020, https://www.state.gov/wp-content/uploads/2020/05/What-is-MCF-One-Pager.pdf.
[21] China Pathfinder: Annual Scorecard, *Atlantic Council* (2021), 1–68, https://www.atlanticcouncil.org/in-depth-research-reports/report/china-pathfinder-2021/.
[22] 117th Congress, "U.S.-CHINA ECONOMIC AND SECURITY REVIEW COMMISSION," *First Session* (2021), 1–551, https://www.uscc.gov/?
[23] Soumitra Dutta, Bruno Lanvin, Lorena Rivera León, and Sacha Wunsch-Vincent, "Global Innovation Index 2021: Tracking Innovation through the COVID-19 Crisis." In *The World Intellectual Property Organization*, 14th ed., 1–226, Switzerland: Geneva 20, Switzerland, 2021. https://www.wipo.int/wipo_magazine/en/2021/03/article_0002.html.
[24] Office of the Secretary of Defense (OSD), "Military and Security Developments involving the People's Republic of China 2020: Annual Report to Congress," *OSD* (2020), 1–200, https://www.defense.gov/News/Releases/Release/Article/2332126/dod-releases-2020-report-on-military-and-/.
[25] "Unicorns by Country 2021," Statista, accessed May 19, 2022, https://www.statista.com/statistics/1096928/number-of-global-unicorns-by-country/.

Annex A. Finance Innovation for Ukraine Support

On April 21, 2022, the Pentagon announced the United States would provide Ukraine with 121 Phoenix Ghost tactical unmanned aerial systems manufactured by AEVEX Aerospace. Although public information is limited, the Pentagon stated that the Phoenix Ghost drones are single use "kamikaze" drones designed to detonate on impact with a target.[1] This was not the first time the Pentagon sent this type of weapon to aid Ukraine's fight against the Russian invasion; however, it was the first time that the U.S. procured weapons specifically for Ukraine rather than sending existing inventory.[2] The U.S. should expand this new practice of identifying innovative capabilities to aid Ukraine while supporting U.S. defense innovators.

The U.S. continues to levy substantial sanctions on Russia and key individuals over Russian aggression against Ukraine.[3] While sanctions put pressure on the Russian government, the U.S. is allocating additional aid packages to directly support Ukraine. Beyond these efforts, the Department of Defense (DoD) should provide dedicated funding to U.S. defense suppliers and start-ups developing early-stage capabilities. This action should use funding supplied through the Ukraine Security Assistance Initiative of the 2022 National Defense Authorization Act, reinforcing the continued pledge of the United States to provide security support to Ukraine during the crisis.[4]

This policy change benefits U.S. national security, Ukrainian military capabilities, and the defense innovation sector. Providing direct funding to early-stage defense and dual-use technology developers to rapidly procure tangible products strengthens U.S. companies and start-ups attempting to scale their business to bridge the dreaded "Valley of Death" from investment to revenue generation.[5] DoD funding of innovative defense technologies also sends a clear demand signal to the market and potential investors. Small businesses and start-ups can develop

new products based on commercial technology on a much shorter timeline than defense prime contractors and the traditional DoD acquisition process, which can take years. Additionally, Ukraine provides an opportunity for live-fire field testing of technologies and weapons in the early stages of development. This translates perfectly for the development and procurement of weapons that might eventually be acquired by NATO to counter Russian threats without the traditional lengthy and costly test and development cycles.

The United States must mitigate the potential risks of transferring new solutions to Ukraine. Introducing technology in early stages of development risks premature technology transfer. Systems that might eventually be classified and export restricted could become essentially open source. The U.S. will also have to navigate the challenge of connecting U.S.-based developers with Ukrainian users to ensure they receive relevant capabilities. Communication between suppliers and end-users will be required for all support functions of the weapons, such as training, maintenance, troubleshooting, and consulting. The U.S. has overcome these challenges with the Switchblade, Phoenix Ghost, and other weapon systems.[6] The speed of new technology development and adaptation mitigates some of this risk, as does the potential to focus on applying commercially available technology to military problems.

The U.S. should implement this policy recommendation through innovation organizations already resident in the DoD infrastructure, such as AFWERX, SOFWERX, the Defense Innovation Unit, and others. This allows the U.S. to leverage previous relationships between the DoD and industry providers through methods familiar to the providers. Further, DoD should extend its engagement to defense-focused venture capital firms, many of which are eager to support both Ukraine and U.S. national security. Their venture funds could serve as a force multiplier for DoD dollars while spurring the next generation of defense innovators.

[1] "Pentagon Reveals Secretive New Drone the Air Force Is Giving to Ukraine: Phoenix Ghost," *Air Force Magazine* (blog), April 21, 2022, https://www.airforcemag.com/air-force-rapidly-developed-a-new-drone-for-ukraine-phoenix-ghost/.
[2] Isabel Van Brugen, "How Phoenix Ghost Drones Will Help Ukraine Deliver 'Punch' to Russian Army," Newsweek, April 22, 2022, https://www.newsweek.com/pentagon-phoenix-ghost-tactical-drones-ukraine-russia-invasion-1699980.
[3] U.S. Department of the Treasury, "Ukraine-/Russia-Related Sanctions," U.S. Department of the Treasury, accessed May 4, 2022, https://home.treasury.gov/policy-issues/financial-sanctions/sanctions-programs-and-country-information/ukraine-russia-related-sanctions.
[4] U.S. Department of State, "U.S. Security Cooperation with Ukraine," *United States Department of State* (blog), April 25, 2022, https://www.state.gov/u-s-security-cooperation-with-ukraine/.
[5] Jason Fernando, "What Does Death Valley Curve Mean?," Investopedia, July 16, 2021, https://www.investopedia.com/terms/d/death-valley-curve.asp.
[6] Van Brugen, "How Phoenix Ghost Drones Will Help Ukraine Deliver 'Punch' to Russian Army."

ANNEX B, Bullet Background Paper Summary, Financing for Innovation

EXECUTIVE SUMMARY: The strategic environment that underpins the creation of capabilities for national defense has dramatically changed over the last 30 years. Domestically, the industries that facilitate and produce defense capabilities have diverged from a Cold War acquisition model. Internationally, the U.S. has a geopolitical competitor in China with unprecedented economic parity that is adapting a civil-military fusion model to accelerate the incorporation of commercial gains for military means. Considering the significant resources spent on defense, the only viable alternative to access the disruptive innovations that facilitate asymmetric advantage is by realigning our system by accelerating commercial technologies for defense purposes through the additive process of leveraging U.S. and ally strength in the private financial industry.

STRATEGIC ENVIRONMENT

- An increasing U.S. budget deficit and declining public sentiment for defense spending necessitates resource neutral actions or leveraging alternative financing sources[1]
- The source of U.S. research and development (R&D) spending has shifted from 58/41 defense/commercial to 20/70 defense/commercial over the last 65 years; commercial advances are outpacing defense.[2]
- The number and diversity of prime defense contractors have decreased from 51 to five since the 1990s[3]; summarily, over the last 10 years, the number of competed requirements has decreased from 60% to 50%[4]; competition is necessary for innovation[5]
- Traditional contractor independent R&D is decreasing with 80% spent on short-term commercially profitable projects rather than on defense priorities[6]
- China, main competitor, has unprecedented economic parity and has created a state-driven Civil/Military fusion system to leverage advances within Commercial R&D[7]

RISK CAPITAL STRUCTURE, CONDUCT, AND PERFORMANCE

- The U.S. has one of the largest and most resilient financial industries on the globe[8]
- According to the Global Competitiveness Report, the U.S. has the highest entrepreneurial spirit, which is complemented by the highest national imperative to incentivize and expand patient investments in R&D, innovation, and markets of tomorrow[9]
- The commercial industry is awash in capital, and the median deal size ($15 million) is at an all-time high[10]
- The U.S. risk capital industry funds the following industries: Software (36%), Biotech (17%), Media/Entertainment (10%), Medical Devices 7%, IT Svs (6%), Energy (6%), Fintech (3%), Networking (2%)[11]

DOD INNOVATION NETWORK AND CHALLENGES

- Over the last five years, the DoD has created 28 separate lean innovation organizations to accelerate access to commercial technologies for defense purposes[12]
- Congress has authorized additional tools, Other Transaction Authorities (OTA) and Commercial Solutions Openings (CSO), to ease access to technology while pockets of the innovation networks have begun leveraging current tools (Pitch Days, Small Business

Innovation Research-SBIR, and venture capital-VC inclusion) to bring in private finance and new technology firms

- Regardless, significant challenges exist within the current innovation network;
  - Although the opportunity is robust, the DoD is not even spending the federally mandated 3.2% of their R&D budget, $2.03 billion, to access commercial sources of disruptive innovation
  - The pockets eliciting and engaging private risk capital are few and far between, with only three organizations with recurring risk capital access; AFWERX alone has stimulated $483M of private finance towards defense priorities[13]
  - Across the last 30 years, only three companies have transitioned from inception to competitor (SpaceX, Palantir, and Anduril); each was founded/funded by a billionaire
  - The Congressional and DoD innovation tools are not permeating the traditional acquisition system nor scaling to meet private financing requirements and operationalize new technologies
  - Risk capital is currently incentivized to finance industries with short-term, 5-year, profit windows rather than emerging technologies with national security priorities[14]
  - The U.S. is losing foundational human expertise relative to global competitors

POLICY RECOMMENDATIONS

- The intent is to leverage domestic and global private finance to accelerate the expansion and scale of new technologies into the military and increase company competition in the defense industrial base

- Innovation Theme #1: Recalibrate the DoD Innovation Network
  - Minor REC #1: Establish a SBIR fund baseline and increase R&D allocation to 4%
  - Minor REC #2: Expand DoD's Innovation Ecosystem to the National Technology Industrial Base (NTIB) military and equivalent small businesses
  - Minor REC #3: Establish a DoD Loan Program Office (LPO) with a venture debt program for hardware or emerging technology start-ups and a loan guarantee program

- Innovation Theme #2: Scaling to Bridge the Valley of Death
  - Minor REC #1: Establish a Small Business Innovation Production (SBIP) Fund at 1% DoD Production Budget
  - Minor REC #2: Realign the Demand Side
  - Minor REC #3: Incentivize traditional contractors to subcontract with DoD Manufacturing Initiative companies

- Innovation Theme #3: Improving Human Factor Conditions
  - Minor REC #1: Expand STEM programs across basic and higher education
  - Minor REC #2: Create a new visa category for entrepreneurs
  - Minor REC #3: Support the advancement of financial technology

[1] David Andolfatto, "MacroMania: Is the U.S. Budget Deficit Sustainable?," *MacroMania* (blog), May 25, 2019, http://andolfatto.blogspot.com/2019/05/is-us-budget-deficit-sustainable.html; Craig Kafura, "Republicans, Democrats Split on Increasing US Defense Budget," Research (The Chicago Council on Global Affairs, December 17, 2020), https://www.thechicagocouncil.org/research/public-opinion-survey/republicans-democrats-split-increasing-us-defense-budget.

[2] John F Sargent Jr, "U.S. Research and Development Funding and Performance: Fact Sheet," *Fact Sheet*, n.d., 6.

[3] "State-of-Competition-Within-the-Defense-Industrial-Base," n.d., 4.

[4] "State-of-Competition-Within-the-Defense-Industrial-Base," 3.

[5] "State-of-Competition-Within-the-Defense-Industrial-Base," 2.

[6] "Most of Industry's R&D Spending Doesn't Match DoD's Priorities, Report Says," Federal News Network, September 14, 2020, https://federalnewsnetwork.com/dod-reporters-notebook-jared-serbu/2020/09/most-of-industrys-rd-spending-doesnt-match-dods-priorities-report-says/.

[7] "Comparing United States and China by Economy - StatisticsTimes.Com," accessed May 10, 2022, https://statisticstimes.com/economy/united-states-vs-china-economy.php.

[8] "2020 Banking Industry Outlook | Deloitte US," accessed May 10, 2022, https://www2.deloitte.com/us/en/pages/financial-services/articles/banking-industry-outlook.html.

[9] "Global Competitiveness Report 2020," World Economic Forum, 39, 46, accessed May 10, 2022, https://www.weforum.org/reports/the-global-competitiveness-report-2020/.

[10] "These 6 Charts Show How Much VC Is Awash in Capital in 2021 | PitchBook," accessed May 10, 2022, https://pitchbook.com/news/articles/2021-us-vc-fundraising-exits-deal-flow-charts.

[11] "These Are the Industries Attracting the Most Venture Capital," World Economic Forum, accessed May 10, 2022, https://www.weforum.org/agenda/2017/02/these-are-the-industries-attracting-the-most-venture-capital/.

[12] "Tap the Innovation Ecosystem | AiDA," accessed May 4, 2022, https://aida.mitre.org/demystifying-dod/innovation-ecosystem/.

[13] Eric Lofgren, "AFWERX Companies Starting to Transition, but Jury's Still out Scaling Transformation," *Acquisition Talk* (blog), January 18, 2022, https://acquisitiontalk.com/2022/01/afwerx-companies-starting-to-transition-but-jurys-still-out-scaling-transformation/.

[14] "These Are the Industries Attracting the Most Venture Capital"; "Critical and Emerging Technologies List Update.Pdf," accessed May 3, 2022, https://www.whitehouse.gov/wp-content/uploads/2022/02/02-2022-Critical-and-Emerging-Technologies-List-Update.pdf.