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INTRODUCTION

Over the past few decades, an ecosystem of companies and structures has emerged that encourages and supports innovations and their transition into viable products. Venture capital (VC) markets and VC firms are prime examples of such support structures. These and other structures first developed in the commercial marketplace, which we might call the "commercial innovation system." Similar structures are increasingly being adopted, sometimes in different forms, in government and national security environments.

Recent policy discussions of the US Department of Defense and congressional oversight committees have used the term "National Security Innovation Base" (the NSIB) to describe those elements that support national goals. These elements can be categorized, and best practices from the commercial system can be applied to foster innovation in national defense. Inevitably, however, we must confront the complex notion of "innovation" given current components and participants, and how innovation in the traditional commercial sector is being transformed for applications across the NSIB.

An overarching issue in support of innovation is the attribute of *time*, as required for the development of an idea, to change course, and overall time to market. Commercial technology markets have developed platforms and methods that accelerate the time scale to rapidly grow startups into unicorns to lead the contemporary world's largest and most advanced economy. Speed is a primary goal of commercial innovation systems in all aspects of development.

The issue is how to develop analogous platforms in the national security sector that can bring similar value to the NSIB and, therefore, US national security. The structures needed to support the rapid development of capabilities are in place. However, the arduous process of innovation demands patience as these platforms emerge and disrupt the status quo of research and development (R&D) and procurement within government contracting systems of national security.

Take-aways from the Commercial Innovation System

Innovation can be taught and tracked. The enablers in the national security innovation base (NSIB) have been engaged in teaching and tracking innovation, but are still in the early stages of learning and applying lessons learned from private sector innovation systems.

Historically, government investments have been most useful for innovation generation and in basic research phases. Enabling can mean funding research and development, but just as important are the validation, feedback, and test and evaluation processes that flow from becoming an early customer, and the financial leverage that authentic government interest can stimulate.

When innovation enablers in the US federal government (such as those funding R&D) are willing to accept manageable risk, they can help spur innovation that might not be of significant interest to venture capitalists without government interest.

Having an idea is not enough. Developing ideas and scaling them so that they can spur an enduring customer response—whether for government (e.g., defense) or commercial purposes, or both—requires work and capital, which are influenced by time. Typical government contracting takes too long. Enablers that help accelerate the process can only work if government allows rapid transition to production and use (in some cases, this means getting out of the way).

Applying technological advances to defined mission sets also requires agility, and a willingness to change focus quickly. The concept of "failing fast" is just as relevant in national security ventures as in the commercial sector. In many cases, this means abandoning a direction, and allowing personnel and funding to move onto other important efforts without prejudice to status or careers.

These same concepts apply to the organizational structures that support innovation growth within the NSIB. Although tailored to the military service or mission they hope to innovate, these organizational structures must continually seek creative destruction as they collaborate with similar structures across the NSIB community, and tune their work toward greater impact.

INNOVATION

While many definitions exist, the commercial sphere recognizes innovation as the **creation and execution** of something new that provides real value for the customer, for which they will readily pay. Within the NSIB, we suggest that an operational definition of innovation is the **creation and execution** of something new that increases US national security, for which the government and its taxpayers agree to pay.

To date, some have confused **invention** with **innovation**. While both are certainly important elements, invention alone is not the rigorous process of turning a new idea into something of value.

A prime example of commercial innovation is the development of the smartphone: a single pocket-sized device that is a phone, calculator, word processor, web searcher, calendar, portable storage and gaming device, sensor suite, flashlight, and more. It accelerated the rise of a small personal computer firm (Apple) into a trillion-dollar company (in valuation) with global customers, thereby generating numerous competitors for both hardware and software elements.

An example of innovation in the national security sphere would be a transformative capability that renders a current threat harmless. As well, it could be a new weapon system that renders a prior class of attack systems obsolete. The military and intelligence agencies are customers of innovative solutions, as they acquire missiles, satellites, planes, ships, tanks, armaments, drones, and other tools to serve and sustain national security.

While the differences between the commercial and NSIB markets are clear, these markets share key elements that drive and develop innovation. Common to both are 1) innovators that found companies offering ideas and solutions, and 2) the constant search for capital and revenues to fund R&D and company growth during the embryonic phases. Such similarities are strongest in the need to progress to a self-sustaining revenue model as quickly as possible; to minimize expenses of early-stage development, and to beat competition to market.

A HISTORY OF DEVELOPMENT OF INNOVATION SUPPORT

The first VC firm, American Research and Development Corporation (ARDC) was formed in 1946 by Georges Doriot, a Harvard professor and naturalized French citizen who served in the US Army as a Brigadier General under General Eisenhower's wartime push to harvest ideas from science and industry. ARDC's 1957 investment of $70,000 for 70% of Digital Equipment Corporation (DEC) garnered $35.5 million in 1969 at an initial public offering, 500 times the original investment, for an annual growth rate of 330%.[1]

Figure 1. Innovation Structures in 2023

Innovation Structures in 2023

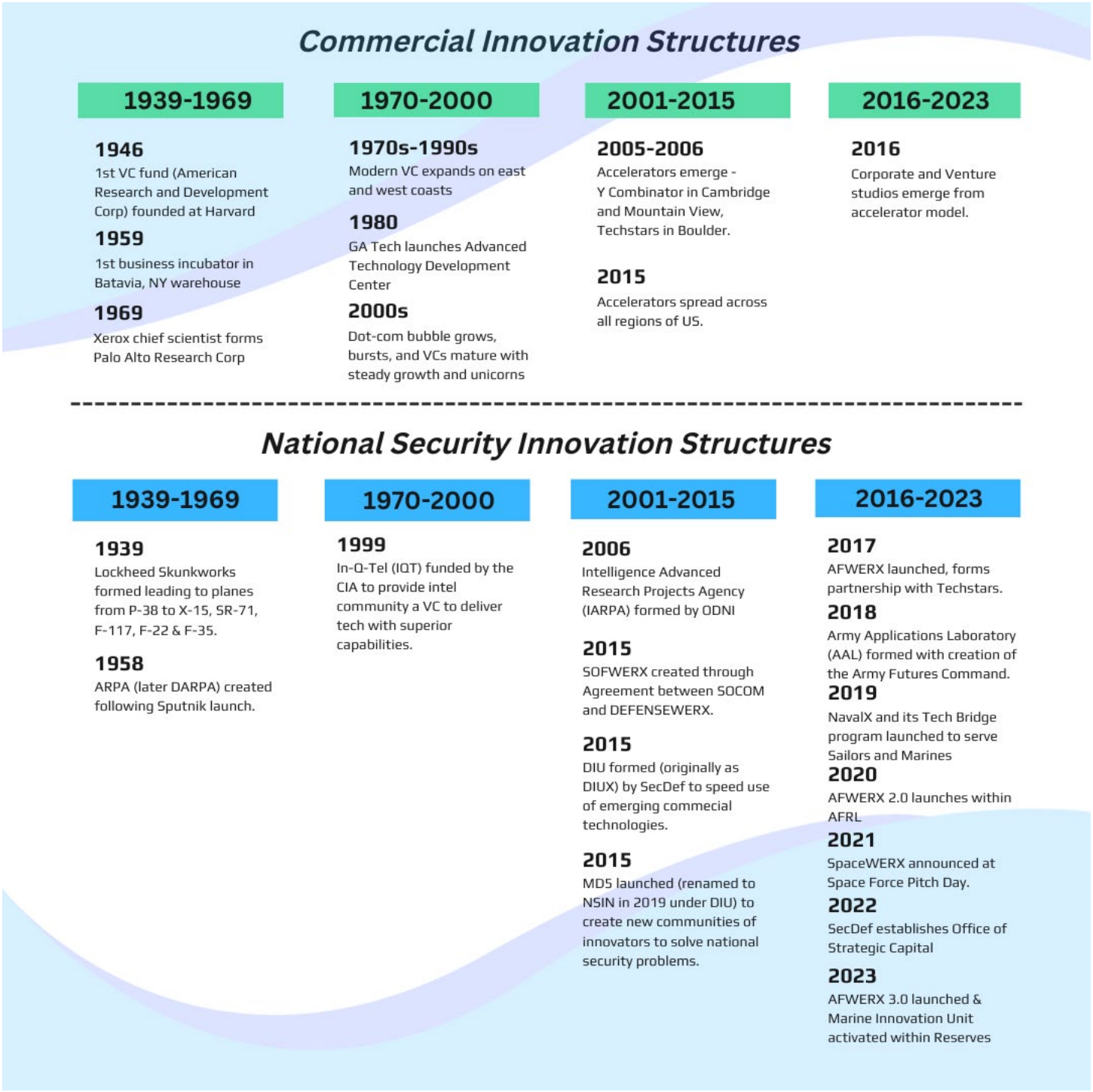
Type	Global	US
VC Funds	27000+	12000+
Private Equity Funds	15000+	6000+
Angel Investors	3,000,000+	600,000+
Angel Investor Groups	4000+	95+
Tech Incubators	7000+	2000+
Technology Parks	5000+	1500+
Accelerators	5000+	2000+
Studios	850+	425+
Corporate Venture Incubators/Funds	3000+	1500+

In the 77 years since, the number of VC firms around the globe has grown to over 27,000, of which 12,000 are in the United States.[2] One of the most prolific and successful early-stage entities is Y Combinator. With offices in Cambridge, MA and Silicon Valley, CA, Y Combinator was formed in 2005 as an accelerator program that coached and funded select founders in groups (called cohorts) to create a cadenced stream of emerging tech startups. Another accelerator, Techstars, was founded in 2006 in Boulder, Colorado, and now has over 20 locations on 6 continents, providing mentor-driven coaching, as well as funding venues for early-stage technology companies that apply to join its cohorts. Figure 1 displays the many different types of innovation structures currently present in the commercial space.

In the national security space, the nation's first jet fighter, the 1945 Lockheed P-80 "Shooting Star" which became the fastest plane at the time, was developed in a separate engineering department that become known as the "Skunk Works." In 1958, the Advanced Research Projects Agency (ARPA, now DARPA) was formed in response to the surprise launch of Sputnik, with the explicit goal of accelerating innovative developments.

Figure 2 presents key milestones in the formation of structures within US commercial and national security markets that were created to harness speed and innovation. The

Figure 2. Key milestones in the formation of innovation entities.



growth in such structures since 2000 is notable, producing market-tailored entities that unite innovators, problems, ideas, prototyping, and funds to reduce time, risk, and cost to market.

THE ART OF DEVELOPING INNOVATION

Innovation as a process can be taught and learned. For example, Distinguished Professor Dr. Merrick Furst leads the "Deliberate Innovation" program at the Georgia Institute of Technology. Previously, Dr. Furst co-invented probabilistic circuit analysis and planning graphs, which are key breakthroughs in the field of AI planning. His work on innovation led him to found Flashpoint at Georgia Tech, an "accelerator studio" that draws on behavioral economics research to build "formative leaders and exceptional technology startups."[3] A primary lesson in such programs is that the discipline of innovation takes practice and patience to reduce risks and consistently achieve desired results.[4]

In the 2022 World Economic Forum ranking of innovation, four of the top five cities for innovation were in the US. In the ranking of innovation talent, the US had six of the top ten cities on the globe.[5] The size of US free markets and the persistence of the innovator community continue to impress and influence world markets. However, both allies and adversaries of the United States are moving up in these rankings each year, spurred by the success of US elements of innovation in both commercial and defense applications.

COMPONENTS OF THE NSIB

Many of the underlying reasons for success of innovation in the national security environment relate directly to the strength of the individual components of the NSIB, which are here organized into three groups: enablers, innovators, and users/implementors.

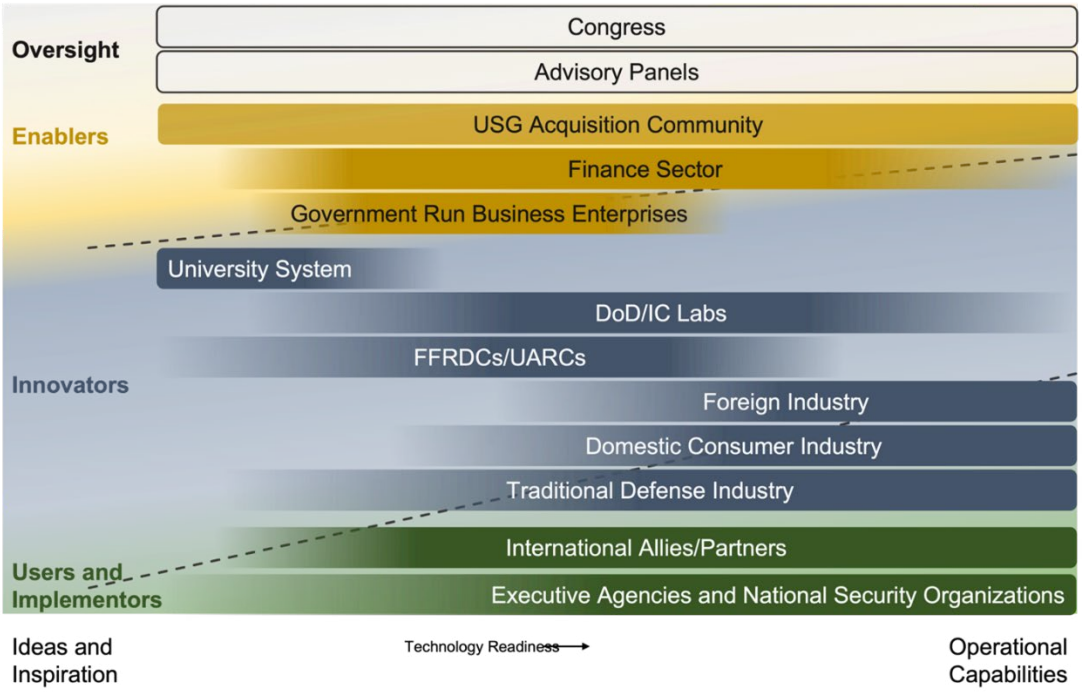
These are the entities that can benefit from lessons learned in the commercial innovation system. Figure 3 illustrates the kinds of entities in each group, and the degree of maturity in the development process that is the focus of each set of components.

Enablers

The group of enablers is comprised of the entities that fund the NSIB, as well as organizations and individuals that catalyze the innovation process.

US Government funding for the NSIB comes from the US congressional authorizations and appropriations, and the DoD budget planning process, which generates requests to Congress in the President's budget. These government funds provide R&D support to government employees and contractors throughout the nation, as well as to international allies and partners. However, the NSIB and its innovation enablers draw significantly more funding from investors through the nation's public and private financial markets, including exchanges on Wall Street, private equity firms, and

Figure 3. Components of the NSIB



the world's first and largest VC and angel capital community. VC firms and angels not only provide the earliest and riskiest seed capital, but also continue to fund development and growth until profits can be generated. The VC and angel funds are integral to programming and mentorship at startup accelerators, incubators, and studios nationwide, including corporate accelerators and maker spaces engaged at several defense primes. Investments can target purely commercial applications, national security applications, or both. Other than government investors, investors generally do not have a market preference for how future profits will be generated.

In the commercial space, accelerators have launched and invested seed capital in over 10,000 startups across the economy.[6] Moreover, their programming is so varied and strong that companies as diverse as Coca-Cola, Microsoft, JPMorgan, Comcast, and Stanley Black & Decker have used them to tailor innovation platforms for their respective sectors.

While it is true that most startups fail, failing founders will often start again in the same or a new market space. Much like the Army's Ranger School, this cycle creates a fast but powerful training ground for innovation leaders, which rewards success, but also values the experience and awareness that comes from failure followed by persistence.

Within the national security space, the government has been accelerating its structures for innovation enablers. In 2017, the Secretary of the Air Force announced a program called AFWERX to open "Air Force doors to highly innovative problem solvers with small amounts of money in ways that strip out bureaucracy."[7] At the same time, it opened applications to the first cohort of its accelerator program, which was managed for the Air Force by Techstars.[8]

In 2020, three core activities were shaped within AFWERX: Spark, Prime and an integrated fund named AFVentures. By 2023, AFWERX presented its 3.0 model, as a directorate of the Air Force Research Laboratory, with an annual budget of over $1 billion to accelerate change in the Air Force, focusing on the department's "Operational Imperatives" and fielding capabilities: "linking them to the procurement funding necessary to turn these projects into delivered capability at scale."[9]

Today, all US military services run accelerators. Examples of these organizations are AFWERX, CATALYST, MIU, NavalX, SOFWERX, SpaceWERX, and XTech. Other structures have been created to organize responses to specific challenges, such as the Department of the Air Force's DAF-MIT AI Accelerator. Others identify and activate innovative service

members who can bring specific mission problems forward, and/or identify and engage university and venture groups working in science and technology with dual-use applications. This is the focus of the National Security Innovation Network—the NSIN (formerly the MD5 Accelerator).[10,11] In many of these organizations, military end users collaborate directly with technology entrepreneurs and their firms to both communicate warfighters' priority technology needs and discover and develop emerging technologies. This is a remarkable expansion of government endorsement of innovation development for national security purposes.

As these accelerators and other structures were established, the DoD tested and launched a comprehensive defense-focused VC fund, the Defense Innovation Unit (DIU), that is run by a VC team with offices in Silicon Valley, CA; Washington, DC; Austin, TX; Boston, MA; and Chicago, IL. At the close of FY 2022, DIU's annual report presented 17 prototype contracts to commercial firms that transitioned during the year to follow-on contracts with defense customers across DoD, with a potential production value of $1.3 billion. This brings the total since 2016 to 52 transitions. Of these, 16 have transitioned into a Program of Record across multiple Program Executive Offices (PEOs). In total, DIU reports leveraging $30 billion in private investment, with $4.9 billion in production contracts to commercial firms, starting with 359 awards for prototypes.[12] After substantial increases in the DIU budget in FY 2023, there are proposals for a greater increase in FY 2024, potentially providing over $1 billion in appropriations.[13]

With the start of a new fiscal year, DIU announced its 3.0 program under new director Doug Beck, a former Apple global VP.[14]

> We will be a fast follower where market forces are driving commercialization of military-relevant capabilities in trusted artificial intelligence and autonomy, integrated network system of systems, microelectronics, space, renewable energy generation and storage, and human-machine interfaces.
>
> —2022 National Defense Strategy[15]

Thirty days after the release of the 2022 National Defense Strategy, the Secretary of Defense announced the creation of the Office of Strategic Capital to integrate efforts across DoD to "develop, integrate, and implement proven partnered capital strategies to shape and scale investment in

critical technologies."[16] This new initiative is yet another demonstration of the consistent support for the unique service-specific innovation entities and the newly emergent DoD structures across the Secretaries of Defense in multiple administrations. The detailed study and stature of the Defense Innovation Board lends credence to the findings and recommendations embodied in its Strategic Investment Capital Task Force report of July 2023 entitled "Terraforming the Valley of Death."[17]

Innovators

The group of innovators is comprised of scientists, engineers, university professors and students, entrepreneurs, corporate innovators, members of the military services, DARPA contractors and integrated defense firms, defense agencies, national labs, FFRDCs, UARCs and non-profits. These innovators advance ideas into innovations through experimentation, development of technology, and customer discovery to determine the product and market fit.

At present, innovators are likely to be concentrated in university campuses, technology parks, and business organizations in R&D, and internal Skunkworks groups, as well as in non-obvious places like planning and budgeting organizations. Virtually anyone who is capable of identifying, analyzing, and developing tentative solutions to a problem can become an innovator. Most importantly, innovation can be taught.

Across the economy and among corporate market leaders, thriving innovation programs actively work to discover "the next great thing" for growth as well as survival. The signs of creative destruction are often visible in these programs, including the very units charged with causing innovation. Innovators can develop applications for commercial markets, national security markets, or both. However, there is competition for innovation talent, as true innovators are rare.

Users and Implementors

Users and Implementers are the customers for NSIB innovation. They consist of integrated defense firms, contractors, the military services, and other defense groups applying technologic innovations to mission needs of the warfighter. This is the category where the problems are known and often painfully experienced. Thus, innovators should seek out these organizations as the primary customers for the solutions to problems encountered by end users.

ACHIEVING SCALE

Just as private companies seek to grow and scale their business through innovation, the NSIB also seeks to achieve scale in discovery, development, and application of innovation to national security. As decades of trial-and-error testing have shown, innovation can be deliberate and scaled.

Key indicators of organizations that are preparing to scale are *measurement*, *experimentation*, *self-examination*, *clear priorities*, *open communications*, and *transparency*.

These indicators might seem basic, but they are directly tied to recognition of how and to what extent the organization is on its path to scale. Specific technologies and capabilities must be protected in these early stages. However, the ability to rapidly court their transition from R&D through prototype, to conversion into acquisition programming requires collaboration and communication. These skills are essential to the knowledge base that will help the NSIB find innovation at scale.

The interactions of enablers, innovators, and users combine to produce innovation for the NSIB. Innovation at scale requires increased interaction among these three groups. In the commercial marketplace, major US cities feature multiple accelerators, university incubators, and private tech studios, along with multiple VC firms collaborating and competing in local markets. California's Silicon Valley and Bay area are especially vibrant ecosystems that are home to over 1,000 VC firms. New York City has approximately 120 VC firms. Virtually all innovation hubs also have entrepreneurial universities and innovation support structures.[18,19] Similar hubs exist throughout the nation and the world.

AN EXAMPLE OF SCALING

While it is not often recognized, many of these hubs owe their initial development to government initiatives. Many innovations, at least historically, begin with government needs. In many cases, commercial spin-offs overtake national security developments. For example, in 1993, Congress provided DARPA with funds to close the gap with other nations in the emerging global competition for technologies to build electric vehicles (EVs).[20] The project formed regional consortia of small and large businesses, universities, and national labs. The Congressionally directed program aimed to accelerate electric and hybrid-electric vehicle development in the United States with dual-use benefit to the US military.[21] At the time, many military ground vehicles used

increasing amounts of electrical power for communications and command and control systems, and it was recognized that electric propulsion (in place of internal combustion) would reduce heat signatures and solve other problems for missions. It was also recognized that there would be commercial spin-offs and markets that could help reduce costs to the military market. Subsequently, the development program transitioned to the US Department of Transportation.

At the time, electric drive technology was far from ready for production. Among many challenges was the lack of sufficient power electronics to handle battery charging and discharging, and to control the compact and strong electric motors required for propulsion. The chips needed to make those switching decisions had not yet been designed, and many other supporting technologies needed further domestic development.

Today, the EV market is expanding rapidly worldwide. To reiterate, it is rarely recognized that government funding helped establish the groundwork for some of the technologies that would be required to allow companies to design and build EVs. Only when the market was ready and large enough to make production possible did production begin for consumer purchases. Before the latest consumer electric drive sedans and SUVs, there were prototype hybrid-electric Army Humvees and M113s. Additionally, production of electric and fuel cell-based commercial buses, garbage trucks, and tractor-trailer rigs evolved from the government programs in the United States and within allied markets at major firms.[22,23] A healthy competition for component supply and sourcing (including for lithium-ion batteries) developed around the globe. Without those investments at the time, the emergence of viable consumer EVs might have been further delayed.

One aspect of the government program was crucial to the rapid R&D required to establish key technologies. DARPA employed its Other Transactions Authority (OTA) to contract with regional consortia that managed a diverse portfolio of projects through teaming agreements tied to the OTA structure. With quarterly payments for clear team milestones, funding flowed with progress, and failing projects were quickly shuttered with unspent funds redirected to next-priority projects. Today, other transaction agreements have become far more prevalent, with increasing interest and acceptance within the DoD and other agencies, and encouragement from Congressional authorizers and appropriators. There have been numerous amendments to the law for OTAs in the years since Congress first authorized them for NASA in 1958, culminating in the current Sections 4021 and 4022 of title 10 of the US Code.[24,25, 26]

As EVs emerge on global markets, there is no doubt that the technologies have spread worldwide, and that now US firms are in a global race to dominate markets. EV factories exist in the United States, Europe, and especially Asia. However, it is not certain that the United States capitalized on its technology investments as rapidly as possible. Thus, another important aspect of innovation is to be first to find a repeatable market for ideas and technology because ideas are rarely unique or protected for long.

NEXT DIRECTIONS

The list of NSIB enablers continues to grow. In December 2022, the Secretary of Defense announced that the Office of Strategic Capital will "scale investments" between existing innovation units, and to increase "the capital available to critical technology companies to help them reach scaled production."[27] The DIU is undergoing transformation with the appointment of a new director from a private sector mega-cap tech firm, higher reporting visibility, and a significant increase in funding proposed for FY 24. DARPA, the Services, other organizations within DoD, and other government agencies from NASA to the Department of Transportation are making greater use of OTAs to speed contracting and facilitate research advancements.

The US government needs to redouble efforts to track the successes and failures of innovation programs. While contracting tools such as SBIRs, STTRs, and OTAs are building momentum, new tools should be developed. Various authorities in place since the 1950s that are not working need to sunset, while successful enablers of innovation need strengthening. OTAs have earned a respected seat at the acquisition table, and Congress has been gradually expanding their applicability. However, current cost-share requirements in research OTAs inhibit their use in the often-risky basic research arena, where an innovative idea is farthest away from potential revenue generation. DARPA might be a good resource to experiment with lifting this requirement, especially in areas of critical national security need.

The government should also streamline its approach to using loan guarantee authorities to encourage private sector lending into the capital stack of rapidly growing innovative firms in the NSIB. This is particularly the case for hardware

intensive **innovations** that are capital intensive, as these can accelerate development and transition. Historically, **loan guarantee authorities** have successfully been used in defense industrial base applications in the past, including for Lockheed's development and initial production of the C-5 Galaxy aircraft. These **authorities** have also been utilized for emerging technologies to address climate change. For example, the DOE Loan Program Office provided financing **to quickly build new EV factories** for Tesla and Ford as well as battery plants **to supply EV manufacturers**.

Since the pursuit of innovation in national security is tied to addressing near-peer challenges, increased funding for successful innovation programs is warranted. But programming steady increases may be more manageable and defensible than large leaps that create programmatic bullseyes. The work of building top-tier project portfolios is difficult and time-consuming. Predictable funding levels are vital to the ability to rapidly execute initiatives and program transitions.

Each of the Services and agencies with innovation structures must calibrate their mission to the intended users. The goal is to foster innovative capabilities, rather than moving money, or merely counting the number of grants, contracts, and agreements. Measuring outcomes requires patience in assessing capabilities, and persistence in pursuing promising concepts, including assessing means to scale the capabilities for production.

Today, DoD, the Services, and the Intelligence Community are accelerating the tempo of funding, review, change, and execution across their portfolio of innovation organizations. This form of creative destruction is a healthy indicator of these programs' maturity. Acquisition tools (including OTAs) are helpful, but still insufficient to the challenge of compressing time scales. The NSIB needs to mirror what has transpired in the global commercial sector cadenced to the challenges outlined in the National Security Strategy. Most importantly, these nascent structures for the national security sector should adapt models developed in the commercial innovation space to the particular needs and missions of their parent organizations, and should utilize appropriate lessons learned (both positive and negative), from experiences in the commercial arena, especially as related to the need for speed to market.

Such lessons include discovery that innovation can be taught, and that it is important to track progress as innovations are developed, modified, and scaled. And finally, one must execute fast, fail fast, regroup quickly, and persevere.

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