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Developing a Model of National Security Innovation: Systems, Enablers, and Types

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Developing a Model of National Security Innovation: Systems, Enablers, and Types

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Abstract

This paper presents a proposed taxonomy of innovation terms that can be arranged into a larger explanatory model of defense innovation. After outlining the case for a capabilities-based definition of the term innovation, the concept of innovation systems (international, domestic, commercial, military/governmental, and civil-military integrated) is introduced. Innovation enablers are then described as the means or factors to produce capabilities-based innovation. These include diffusion, invention, culture and politics, the industrial base, the workforce, the legal and regulatory environment, finance, leadership, and time. Next, innovation types or strategies are introduced to describe the incentive structures that can be deployed within each innovation system. These types include stasis, minimally reactive sustaining, incremental proactive sustaining, reactive and proactive time-based, revolutionary step change, and disruptive. DoD since World War II has employed each of these innovation types in defense acquisition. Disruptive, revolutionary, and time-based innovation primarily occurred in the early Cold War period until it was primarily replaced in the 1960s by an incremental proactive sustaining model. This model has dominated U.S. acquisition ever since. To compete in any new Great Power competition, defense innovation approaches will need to become more time based and disruptive and more integrated with the commercial innovation system.

Introduction

Innovation is perhaps an overused concept in discussions about national security and business competitiveness. Innovative nations are assumed to succeed on the battlefield and dominate markets. To be innovative distinguishes a company or country from its peers. It is a sought-after goal in commerce as it is government. Whatever innovation is we tend to want more of it. Except when we don't—reflected in the many barriers put in place to maintain a status quo in the balance of power, market share, or employment.

Despite these countervailing pressures, in national security debates calls for improving defense innovation are consistently made in Congress and the Pentagon. Policies are deliberated on the basis of what increases or slows down this innovation. Yet, without further defining what is meant by the term or actually being sought, policy-makers risk talking past one another and making poor decisions. That is important as proposed reforms to the acquisition, budgeting, requirements, technology security, and personnel processes are often linked to what is believed to support "greater" innovation or to protect our current advantages.

In an effort to provide greater clarity and rigor to discussions related to developing new defense capabilities this paper will propose a taxonomy of innovation terms that can be arranged into a larger explanatory model of defense innovation. This effort is informed by the current literature on commercial innovation and by the history of U.S. defense acquisition.

After outlining the case for a capabilities-based definition of the term innovation, the concept of innovation systems—international, domestic, commercial, defense, and civil-military—is introduced. Elements or components within these systems can either serve as enablers or barriers to innovation and comprise the next level of complexity of analysis. These factors such as invention, diffusion, the workforce, or finance are the means or factors to produce innovation. If the wrong policies or circumstances prevail, these supporting functions can also impede desired results within an innovation system.

Next, innovation types are described as part of a spectrum or cycle of innovation strategies. These types describe the workings and outputs of the incentive structures that are deployed within each innovation system (i.e., stasis, sustaining, reactive, proactive, predictive, time-based, incremental, revolutionary, or disruptive). A test of the explanatory benefits of the model is found by describing the history of U.S. defense acquisition through the lens of these concepts.

I do not pretend for this paper to be the be-all end-all authoritative guide to the topic but it is designed to begin a conversation on trying to make more sense out of cacophony of thoughts about defense innovation. Many may disagree with its premises. Hopefully, however, a dialogue on this topic could eventually lead to instilling more discipline in the debate over weapon systems acquisition issues and perhaps even larger discussions of innovation in the global economy in general. While it may be a false hope that armed with a more rigorous classification model better decisions will be made in the future, perhaps at least more effective questions could be asked when promises are made about future innovation and modernization that create expectations for one thing but may deliver another.

Defining One's Terms: What is Defense Innovation?

Innovation in national defense has been a hard concept to describe with any precision. A lack of rigorous definition allows the concept to mean different things to different people that can mask serious disagreement on policy and approaches. Having been involved in many of the acquisition reform debates since the Federal Acquisition Streamlining Act of 1994 (FASA) where leveraging commercial "innovation" was a primary goal, I have watched this dynamic play out in how acquisition law is made, but perhaps more importantly in how the law has been implemented.

We should attempt to measure innovation or at a minimum be able to recognize it when it has happened. I will argue that innovation needs to be discussed in a tangible, capabilities-based manner. This does not just mean the creation of new technology, but just as importantly, how that technology is used. New capabilities created from hardware and software origins can comprise one aspect of innovation and then equally, if not more of a marker of progress, is how a human or group of humans can use this capability in new and different ways.

But first how to get there. Defense innovation, while a critical concept to understand, has proven to be extremely difficult to describe or measure. It is ill-defined as it rests upon the much more nebulous concept of innovation in general. Nonetheless, many areas of inquiry provide insights into refining these concepts. In the field of business management, innovation has received significant attention (Christensen, 1997; Collins, 2001; Drucker, 1985; Kim & Mauborgne, 2005; Thiel, 2015). Although he didn't expressly explore the concept of defense innovation, Christenson (1997) is helpful in not only trying to address the issue of the quality of innovation, but also the effects of innovation.

Another relevant field of innovation inquiry has been in the area of economic history, particularly on the identification of technological turning points and their relationship to economic growth, often with a lag as new technologies require time to be adopted (Gordon, 2012). Defense innovation can be categorized using a classification of significant turning points in defense technologies and capabilities, grouping into historical periods various disruptive technologies such as gunpowder, the longbow, firearms, the machine gun, iron-hulled ships, submarines, tanks, aircraft, radar, the jet engine, missiles, reconnaissance satellites, nuclear weapons, stealth and precision guided weapons, and navigation.

Both of these paths of inquiry are useful for a discussion on defense innovation and helpful in framing questions such as: What is defense innovation? Why focus on technological change? Is there a U.S. defense innovation problem? Are there limits to growth in innovation?

Webster's Dictionary defines innovation as a new idea, method, or device, or the introduction of something new. But newness for the sake of newness may not always define the best types of innovation needed by the Department of Defense or the market. Ideas are important but may be better defined as an initial enabler of innovation. New methods of using technology imply innovation, but improved methods or process that led to the production of new technology capabilities can also be categorized as innovation enablers.

In a practical sense, and at its most basic level, innovation can be looked at as some given output to a series of inputs (financial resources, personnel, equipment or capital, research, or ideas) that come together to deliver some new thing or process that is markedly different from and (this part is key) provides some advantage over the previous output. Innovation is more than just a new thing or process, and to adequately be considered innovative, it becomes necessary to identify this advantage. Attempting to measure or quantify the impact of a new technology or process—generally a subjective comparison of two different circumstances or states in time—is not always easy. Innovation as a concept becomes much more complicated when attempting to come to terms with the *quality* aspect of change, or the level of advantage over the previous thing or process, but that concept is critical. Something may be new and different but may not be better.

Innovation is tangible, but also intangible. It can be software or hardware. It can then be a way to use that software and hardware in new ways. For this effort, innovation is defined as a capabilities-based variable. It is something that is distinct and better than what was used before, and the difference that this new capability can provide is the quality measure of the innovation. Thus, there are two aspects to the capabilities-based innovation equation—a technological or process one and then a quality one.

Innovation is not invention. Invention will be defined subsequently as an enabler of innovation. A key data point for innovation analysis is to be found in the later stages of technology development, particularly in the operational prototyping and fielding of a defense capability or weapon system where operators use and test the system. A similar point in commerce would be at the stage of the marketing of a new product where consumers for the first time decide whether to buy such a product. Most prototyping is useless as a marker for innovation and more appropriately classified as advancing science or knowledge. It is not until a prototype is "operational" where there is a minimally viable product that users can operate and test, and if needed, use on the battlefield or sell in the market.

Once usage happens, a threshold has been crossed that provides for a real basis for analysis. It is for that reason that science and technology development once it has led to a first deployment as a capability is an appropriate measure of defense innovation. When this line is crossed and an operational prototype is created, the acquisition system is in new territory. This aspect of congressional acquisition reform efforts where Middle Tier acquisition and OTA prototyping are linked to operational capability has seemingly been missed by the acquisition community. Prototyping and operational prototyping are different. One furthers knowledge. The other provides capability, albeit without all of the "ilities" being worked *out.* The measurement of defense innovative efforts should first be focused on the physical weapons system capabilities that are tested, deployed, and used by a military force.

Thus, on one level, defense innovation can be defined as the changes that are made with technology as demonstrated in the tangible and measurable output of a deployable defense capability. These deployed or operational programs are material and calculable. When trying to measure or define defense innovation, it often becomes practical and logical to focus on weapon systems. This is not only where most data are, but also where there has been the greatest focus of governmental and academic literature on defense management and acquisition.

But focusing just on defense technology or solutions is incomplete. Defense innovation also occurs in many other non-technology areas, and just because there is not a 50-year history of Selected Acquisition Reports data to analyze in a sector does not mean that innovation is not happening. Process innovation can be argued as being equally as disruptive or innovative. In looking beyond defense technology, defense innovation can be found in a number of personnel, process, and operational adaptations.

Innovation can occur through the use of different strategy and tactics, such as the application of forces and technology in new combinations, for example, the Blitzkrieg of the 1940s, the Airland Battle of the 1980s, the concept of All Domain Operations, or potentially "Mosaic Warfare" in the future. The French had more tanks than the Germans at the start of WWII, but they also had a different and ultimately unsuccessful concept of operating them. James Q. Wilson thought the secret to the German success against France was better organization: "The key difference between the German army in 1940 and its French opponents was not in grand strategy, but in tactics and organizational arrangements well-suited to implement those tactics. Both sides drew lessons from the disastrous trench warfare of World War I. The Germans drew the right ones" (Wilson, 1989).

Finally, when coming to terms with innovation, we have to be extremely careful not to be obsessed with data. Just because something can be measured and there is data, we tend to want to focus on that and then risk extrapolating a wrong conclusion. Many of the most important variables may not be conducive to quantification. Intuitive and sometimes subjective analysis in these cases will be more important to policy-makers. Inevitably, if innovation is judged to be capabilities-based, the quality of this innovation will be a subjective call until it is used in a conflict or has been judged in the commercial marketplace. If we only focus on what we have data for, it is highly likely we will miss some hugely important idea and prospect for future innovation. The widely attributed to but unverified comment of W. Edmunds Deming, "In God we trust. All others must bring data," is helpful in certain types of innovation, particularly in the incremental quality-based management process that Deming advocated, but may close out pathways to more disruptive innovation.

Innovation Systems: International and Domestic, Commercial, Defense, and Civil-Military Integration

After defining innovation as the creation and adoption of new technological, process, or use-case capabilities that are better than before it is important to understand where any of this innovation is taking place. In this section, I will begin with proposing a foundation of one overarching international innovation system comprised of many separate domestic innovation systems. Within each domestic system there exists a commercial and a governmental defense system that normally act in parallel and separate from each other. A third distinct and often superior domestic system occurs when interaction is incentivized between the commercial and defense systems that can be described as a civil-military integrated (CMI) system.

As much as many may currently despair of globalization, a global system that eventually leads to technology and knowledge transfer has always existed. The timeframes of this transfer say in the Bronze or Iron Ages may have been incredibly slow, but interaction and technology and knowledge diffusion eventually did occur—ether by conquest, migration, or espionage. We have essentially been living in an international system of innovation since the dawn of agriculture or when humans first picked up a stick and used it as a tool. The difference is the rate of diffusion of knowledge or technology. That rate has been radically ramped up in the information age.

Within the international innovation, system creation and adoption occur at uneven rates in different geographical units and economic systems. Thus, the international system is comprised of potentially hundreds of separate domestic innovation systems (Figure 1). The level of interaction between these domestic innovation systems will vary by the level of globalization and trade, conflict, and the establishment of military alliances. New capabilities, whether embedded in new technology or new ways of using technology, have usually occurred in one national domestic innovation system and then diffused to other systems, although joint research can lead to the development of joint capabilities, for example, the F-35. Still, it is necessary to recognize that while joint innovation programs occur, most innovation primarily resides in competitive nation states with national or regional champions vying for supremacy (i.e., Boeing vs. Airbus or founders toiling in Silicon Valley, the Oxbridge corridor, and Shenzhen) sometimes cooperating across domestic innovation systems, but mostly competing.

There is a strong tendency toward autarky writ large in each domestic innovation system that attempts to limit interaction with other domestic systems in the international system. Countries will often want to protect their intellectual property and advantages created in their domestic innovation systems and reduce any dependencies on other systems. Complete autarky may be impossible, but an attempt to do so will likely lead to unbalanced innovation—breakthroughs on one hand and decline on another. North Korea is a splendid example of an autarkical domestic innovation system seeing advances in nuclear and missile technology while lagging behind in most other technologies and use cases. Ricardo’s concept of comparative advantage still rings true in commercial innovation magnified by a willingness to allow Smith’s invisible hand of commerce drive the Wealth of Nations. A similar effect can be seen in the strengthening of military alliances through the sharing of technological knowledge and joint cooperation.

While markets and military competition and cooperation may indeed be global and international, I will begin this exercise with something simpler by describing one domestic innovation system with the understanding that similar forces are at work in other domestic systems. These many domestic systems of course interact, and as one wants to add in complexity, those interactions can be described and evaluated primarily through the innovation enabling variable of knowledge diffusion. It is far likelier that innovation is occurring first in domestic systems either through domestic market competition or by the internal recognition of external threats that drives defense innovation. The U.S. system is thus one of many domestic or country innovation systems that collectively make up the overarching international innovation system and can be first looked at through its domestic framework.

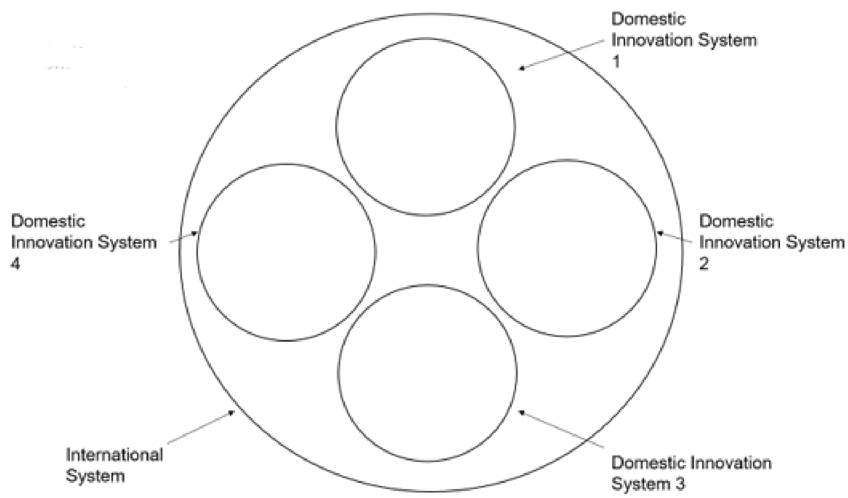

Figure 1. The International Innovation System

At its simplest, the domestic innovation system is comprised of two parts: a domestic commercial system and a governmental backed defense system (Figure 2). These systems are first displayed as tangential to one another and not interacting. This reflects much of the peacetime history of the U.S. prior to WWII. The military system valued the independence of its government operated arsenals and shipyards. It was only in wartime that major interaction between the commercial and military innovation systems occurred at scale. In peacetime that interaction was usually limited to the commercial system selling raw materials into the defense system.

The commercial innovation system essentially operates based on market forces and incentives to address the needs of the consumer and businesses. Wherever the government controls the means of civilian production, that sector of the commercial innovation system moves to the right and becomes part of the military/government system. There would be a very small if not non-existent commercial sector in a traditional communist system like North Korea. Thus, each domestic innovation system in the world is different based on policy choices of what portions of the economy the government decides to control and which is left to the market. Innovation can occur in either commercial or governmental systems, but outputs can vary greatly.

As the United States has found out in its economic history when the commercial and government systems are encouraged and incentivized to interact, some truly amazing leaps in innovation can occur. It was primarily during longer conflicts that a greater degree of this type of integration was allowed to take place. After these conflicts ended, the two innovation systems drifted apart—although this did not completely happen for a time after WWII, which is significant. During these periods of wartime commercial-military cooperation, a push-pull dynamic occurs that immediately leverages commercial technology into the military side while initiating a slower pace of diffusion of military technology to the commercial side. Over the subsequent intervening period of time between conflicts, this technology is then modified and improved upon in the commercial system by market forces (see Figure 3).

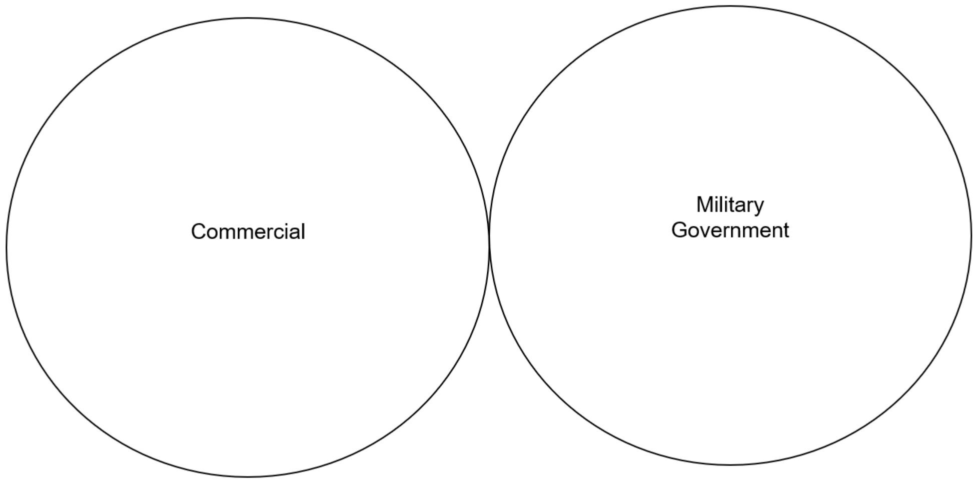

Figure 2. The Domestic Innovation System

There is a direct link between defense and commercial innovation and the two are intertwined. The concept of Civil-Military Integration (CMI) that Jacques Gansler advocated for during the FASA period, and that the Chinese have now adopted as Military-Civilian Fusion, is a real phenomenon and does not need to only happen just in wartime.

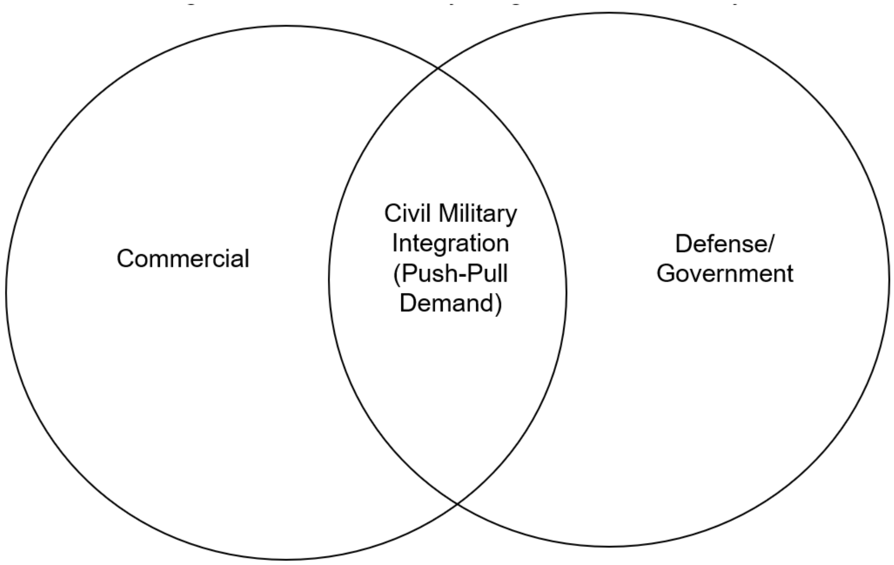

Figure 3. The Civil-Military Integration Innovation System

Defense technological innovation in the United States and elsewhere has been greatly influenced by these periods of cooperation and integration of the commercial and military unique industrial bases. The level of this technological cooperation can be described as the degree of CMI present in the national industrial base at the particular point in time. CMI was a widely-used defense term of art and policy objective in U.S. in the 1990s, but never really gained traction. It became mostly forgotten a decade later. CMI discussions began as a reaction to the rapid rise of commercial R&D that was described by the Packard Commission in the 1980s, but has roots that go back much farther.

For example, the shipbuilding demands of the Royal Navy in the 16th and 17th centuries required complex industrial processes to produce pulleys, rope, sails and other fittings in quantity furthered the development of new technologies and manufacturing techniques that were applied to commercial shipbuilding and vice-versa. The evolving military need for interchangeable parts that would eventually revolutionize commercial manufacturing received its first significant boost through the evolution of cannon production in France in the 1700s (Madhavan, 2015). European improvements in military manufacturing brought forth knowledge that eventually spread to European commercial enterprises and then across the Atlantic Ocean, just as in the last several decades manufacturing knowledge proliferated to China and other parts of the developing world.

This initial diffusion of intellectual property and manufacturing knowhow from Britain and Europe would ultimately lead to the creation of the "American System" of manufacturing or mass production and is a prime example of how the CMI push-pull process works. This began in the Springfield arsenal in Massachusetts in the early 1800s. Mass production's development in the United States was advanced by military research and development generated by the U.S. Army's specific and quite rigorous military requirement to achieve interchangeable parts in gun manufacturing. "Believing that interchangeable weapons would mean easier field repairs and cheaper manufacture, the officers of the Ordnance Department urged development of uniform small arms, with detailed written specifications and gages for inspection purposes" (Raber et al., 2009). This did not happen overnight as it took "thirty-five years of sustained effort at making essentially uniform muskets, succeeding to the satisfaction of Armory mechanics in 1849" (Raber et al., 2009).

The manufacturing solutions for this requirement once developed at the Springfield U.S. Army arsenal eventually spread throughout the U.S. economy (Hindle & Lubar, 1986; Howard, 1978). These techniques were further refined in the commercial marketplace over many decades as workers left the arsenal and built their own enterprises. This knowledge applied to clocks, furniture, bicycles, and eventually automobiles ultimately created the industrial capacity and ability to mass produce at scale.

The development of interchangeable parts at the Springfield arsenal became the first of many examples of the need to solve hard military problems or requirements that exceeded what was available in the commercial marketplace. This triggered research into new technologies, and once these hard problems were solved, that knowledge was eventually transferred back to the commercial sector where it took on a different life of its own. Those advances would eventually return to serve the military in times of subsequent conflict or competition. A similar arc happened after military efforts to miniaturize electronics for ICBM development jumpstarted Silicon Valley in the 1950s, and advances there began to trickle back to the military in the 1980s. In our own era, this dynamic is one that is incentivizing many artificial intelligence, robotics, and data analytics firms to enter the defense market to try to solve difficult military problems and then use the knowledge that comes from that research on more profitable commercial uses.

The reality though is that at least until WWII, CMI in the United States was the exception and not the rule and U.S. defense innovation was episodic. Periodic pockets of U.S. innovation arose in wartime, particularly during the Civil War and World War I. The Civil War saw the introduction of new innovations such as the repeating breach loaded rifle, the machine gun, naval mines and torpedoes, and the iron-clads, along with the adoption of new innovations from the commercial market to military uses (railroads, telegraph, and balloons for aerial reconnaissance).

World War I continued to build on some of these advances but added tanks, submarine warfare, airplanes, flamethrowers, poison gas, and radios to the mix. The first lesson to be learned is that each of these wartime innovations came about or were significantly advanced due to the time constraints of meeting the threat. Thus, time and a sense of urgency is an innovation enabler. Still, like most U.S. defense innovation in the pre-WWII period, these technologies were largely forgotten and unfunded by the government after a conflict and, if applicable, moved out into the commercial market and drove new commercial advances in, for example, continuous wave technology in radios after World War I (Gertner, 2012; Nagle, 1999). In similar fashion, the Civil War propelled the clothing industry into the industrial age through the standardization of clothing sizes.

At times in U.S. defense economic history, the commercial sector has been the lead change agent for technological advancement and at other times military needs drove innovation. David Mowery outlined several cases studies of military to civilian spin-offs: machine tools, commercial aircraft, semiconductors, electronic computers, the internet, and nuclear power (Mowery, 2010). From the late 1800s to the present day, the materials, telecommunications, and transportation industries each grew and expanded, through a push-pull mechanism of national security and commercially competitive needs. As a result, both the military and consumers benefited from the cross-pollination of ideas, research, and breakthroughs in technology, manufacturing, and business practices.

This now seems to be a lesson that China is embracing at scale. It may currently have the best understanding and execution of the concept of CMI (despite its U.S. origin) in its own version of military-civil fusion of its industrial base. Michael Brown, a former head of DIU recently commented on this phenomenon stating “that two-thirds of the business of the top ten suppliers to the Pentagon is defense only; in China, the equivalent figure is 30%” (*The Economist*, 2025). The United States has struggled since describing the concept of CMI in the 1990s with achieving it in peacetime, and the barriers to doing this have resided in the enablers of innovation.

Innovation Enablers: The Factors Behind Innovation

In this section, nine factors are considered that can enable or, as if often the case, serve as barriers to innovation (see Figure 4). These are diffusion, invention, culture and politics, the industrial base, workforce, the legal and regulatory environment, finance, leadership, and time. One may quibble over whether these are the only factors and that others should be included, but for purposes of this discussion, these factors should suffice to start the conversation.

Another distinction to be made is the potential overlap of these factors on the commercial, defense, and civil-military integration innovation systems. In Figure 4, I have singled out diffusion and invention as being substantial common factors that can impact all three innovation systems in relatively the same manner, although understanding that there is some variability in effect. The other seven may evolve more distinct and separate variability depending on the innovation system. This may impact one innovation system in a more dominant way than the others so are identified separately. The reality is these enablers are all related and interact with one another, serving either as building blocks or barriers to innovation. Effective policies designed to enable innovation are necessary in each of these areas and an understanding of their interactions is required to prevent them from becoming brakes on future innovation.

Invention

Innovation must be distinguished from invention. In this context, invention is new knowledge. It is distinct from the creation of a new capability. It is knowledge for knowledge’s sake or if adopting a more goal-oriented view, a stepping stone to innovation. In a defense context this is quite important, as invention is the source of new discoveries and knowledge, funded as research, which then become the building blocks for future innovation. Invention occurs in the university system and in laboratories around the world. In DoD it corresponds to 6.1-6.3 funding levels (Basic Research, Applied Research, and Advanced Technology Development). Advanced component development and prototypes or 6.4 is an invention and innovation grey zone. Where prototyping is for a minimal viable product and thus is a capability that can be used, the line to innovation has been crossed. All other prototyping can be classified as invention. Funding of invention is of course important, but the quality and productivity of this funding is even more so. Research grant funding where a majority goes to unproductive administrative overhead will cause invention to suffer. Process, cultural, and institutional pushback against any so-called Kuhnian paradigm shifts serve as additional barriers to invention. The rise of commercial R&D that overtook government-directed R&D in the 1980s and the subsequent globalization of that R&D infrastructure is perhaps the biggest trend influencing invention and innovation in the modern era. Much of this commercial R&D though is geared to creating new capabilities so is more innovation rather than invention focused. Each innovation system mines the invention ecosystem for its knowledge, ideas, and experimentation results to be incorporated into capabilities.

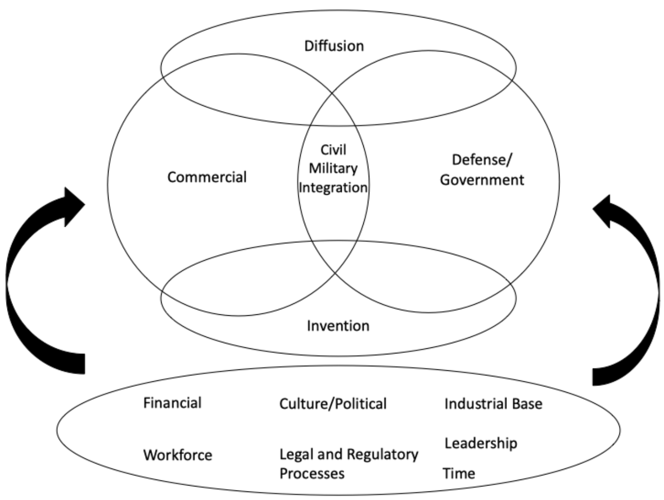

Figure 4: Innovation Enablers

Diffusion

Beyond trade, the foundation of globalization is knowledge and technology diffusion. Because of this diffusion, innovation is taking place in many new areas around the globe. Technology diffusion between companies, countries, and innovation systems occurs through cooperation, duplication, reverse engineering, the stealing of intellectual property, and espionage. Security arrangements and export controls are designed to prevent or slow down this diffusion, but also become barriers to cooperation between actors that the government may want to see work together. These arrangements can serve as a sort of Gresham's Law for innovation by incentivizing behaviors that prevent CMI within a domestic innovation system or between allied innovation systems such as in AUKUS (Greenwalt & Corbin, 2024). Commercial companies desire not to be encumbered with export controls and security mandates and then choose not to work in defense. This leads to the situations where leading technology can be available to the global commercial market but not to DoD.

Regulatory and Legal Processes

Security arrangements to prevent diffusion are just one type of governmental process that can enable or detract from innovation. Governmentally-generated rules in law and regulation establish the underlying process, procedures, and ultimately culture of a defense management system that is organized and divided into various budget, finance, requirements, personnel, acquisition, contracting, systems engineering, security policy, and oversight management regimes. These management regimes, particularly if they operate in a linear manner can result in enormous amounts of bureaucratic time and process hurdles that can slow down and destroy innovation.

To participate in the federal or defense marketplace, a commercial entity must be cognizant of and compliant with these regimes. Depending on how regime incentives are orchestrated, they will have a direct impact on the quality of innovation, the rate or time it takes to innovate, and the level of participation that can be generated from the industrial base. Processes can encourage participation or preclude participation. They can influence the level of innovation that is desired or achieved. This framework, or operating "rules of the game," provide the pathway a public or private sector entity to eventually innovate on behalf of the government, as they are the primary means that influence managers to organize labor, capital, and financial resources to meet defense needs.

Industrial Base

This refers to the productive capacity and industrial structure of an innovation system. It is based on past investments, incentives, and shaped by governmental mandates and processes. The components of the industrial base include the workforce, intellectual property or proprietary knowledge, invested infrastructure, and technologies generated from years of research and development, production capacity, and maintenance and support capabilities of not only military equipment, but also dual-use capabilities that support defense and the wider commercial market.

The organization, nature, and characteristics of who participates in the defense industrial base depend on the resources, funding decisions, and priorities directed at defense; the processes that determine those decisions; the incentives put in place by the government; and the overarching economic market. The current U.S. industrial base of importance to defense includes government arsenals and shipyards, traditional defense companies both large and small, non-traditional contractors to include venture backed emerging technology firms, commercial firms with defense subsidiaries and contracts, allied owned companies, and finally a large portion of the commercial dual use industrial base that has chosen not to do business with DoD.

Education and Workforce

The workforce that directly enables innovation includes entrepreneurs, managers, the STEM (science, technology, engineering and math) workforce, and production labor. The defense acquisition and other management regimes' workforce are also critical and need to have an understanding of how the innovation system works as do regulators, congressional and policy staff, teachers, and university professors. The quality of primary, secondary, university education, vocational training and associated curriculums are key factors in developing the workforce necessary for future innovation. Weakness in any sector of the workforce or educational system can serve as dead weight for future innovation progress. Past federal programs including the GI Bill and the National Defense Education Act of 1958 were instrumental in expanding the number of scientists and engineers at a critical moment of rapid innovation in the United States. Immigration is another critical factor. U.S. innovation efforts in WWII and in the immediate Cold War period were greatly enhanced by the large immigration of highly educated scientists and engineers from Europe who escaped the Nazis in the run up to the war.

Cultural and Political

Culture, norms, and political dynamics are key enablers or barriers to innovation. Significant innovation is highly disruptive to society and a threat to entrenched interests, companies, and workers. Innovation is dependent on an openness to any such disruption. The English political system made some extremely difficult political decisions in the 18th century that enabled the industrial revolution (Frey, 2019). China under Deng made similar calculated risks. A nation's tolerance for risk and change is tested with new innovation by the companies that go out of business, workers that lose their jobs, and politicians who come under pressure to "do something." This can fuel a populist backlash that can smother avenues to new innovation. When modern day Luddites win the culture or political wars, a nation's innovation system can risk inertia and decline.

Leadership

Effective leadership in both the public and private sectors is critical for innovation to succeed. It is leadership that must establish the processes and incentives for innovation to take place and then manage and limit the fallout from potential disruption. Chinese President Xi's initial crackdown on the entrepreneur class can be viewed as a recognition of the political dangers inherent in innovative disruption. His subsequent reversal and rehabilitation of Jack Ma illustrates that China is struggling with the need to be open to disruption and more tolerant of pesky entrepreneurs if it wants to be globally competitive. Leaders determine the types of innovation paths to invest in either with private or public resources. They also are instrumental in putting in place the right mechanisms and incentive structures for other enablers. If leaders don't pay closer attention to the incentives behind the plumbing processes of government and the private sector such as contracting, personnel, or financial systems, a desire for innovation may prove difficult to achieve.

Financial System

Everything must eventually be paid for. The financial system is the engine that drives innovation and the tolerance for risk and desire for return are key factors in this equation. A vibrant stock and bond market and an open and free market that encourages the free flow of investment underpin economic growth, prosperity, and the opportunities for innovation. On the other hand, financial markets will reward monopolistic status quo providers if the returns are high enough and thus inhibit investment in potential disrupters.

The government innovation system is dependent on the success of the overarching commercial system for resources to tax and then invest in its own innovation efforts. The country with the largest economic pie is at an advantage in a global competition. In the defense sector, the willingness of the financial market to invest will determine the health and innovativeness of these companies. Low margins and high regulatory costs as exist in the current DIB will inhibit that investment. Venture capital in the United States has only started to substantively invest in the defense sector in the last decade. Without seeing new entrants increase defense sales at scale, this investment will likely dry up.

Time

Time is an often forgotten variable. A driving factor in innovation success is whether there a sense of urgency or not. As Dan Patt and I have argued, time focuses efforts and weeds out technologies and ideas that are not yet ready to operationalize (Greenwalt & Patt, 2021). It can, if allowed to, constrain bureaucracy, calling for a responsive industrial base and engineering incentives and methods. As we observed, some of America's most innovative periods came about when time as a variable was constrained either arbitrarily or in a crisis. When time is not a variable and there is no compelling urgency, stasis and risk averseness creep into the innovation system.

Innovation Types: Where Innovation Does or Doesn't Happen

The following discussion begins by building on the foundation that Clayton Christenson outlined in his work classifying commercial innovation (Christensen, 1997). His description of commercial innovation types while addressing the relationship between business firms provides a useful nomenclature for describing certain types of defense innovation that arise in the competition between states. Christenson's definitions, though, need to be adapted and take on different connotations when looking at a national security environment rather than a business environment.

The incentives and objectives that Christenson focused on to address why companies fail will be different within a business market than in the national security enterprise, where competition among states is not tested in the same way or as quite as often as in the market. In fact, success in deterrence strategies may involve never having to test the competitive balance between powers. Still, there are enough similarities that the Christenson model of sustaining and disruptive technologies can become a useful explanatory tool in defense. To this initial design will be added the concepts of stasis, reactive, proactive, predictive, time-based, and revolutionary approaches.

In this proposed construct, there are seven innovation types or strategies that can be pursued (Figure 5). A key variable in many of these strategies, as they are in Christenson's analysis, is the degree in which culture change is required. Stasis is the starting point and can be described as the status quo innovation state. Minimally sustaining and incremental proactive sustaining are two types of strategies comparable to Christenson's sustaining model of innovation where innovation happens as a way of maintaining one's competitive advantage and one's underlying culture and outlook do not change. Time-based innovation strategies (both reactive and proactive) can straddle Christenson's sustaining and disruptive concepts modified for a defense application. A revolutionary step change while significant is not quite as substantial of a change that occurs through disruption. Finally, a disruptive strategy is an order of magnitude improvement in the quality of innovation and serves to undermine the underlying culture and outlook. Another key aspect to consider in each of these types is the degree of CMI in the domestic innovation system. CMI will likely achieve greater innovation within each innovation type when compared to just being conducted in the commercial or military/governmental system.

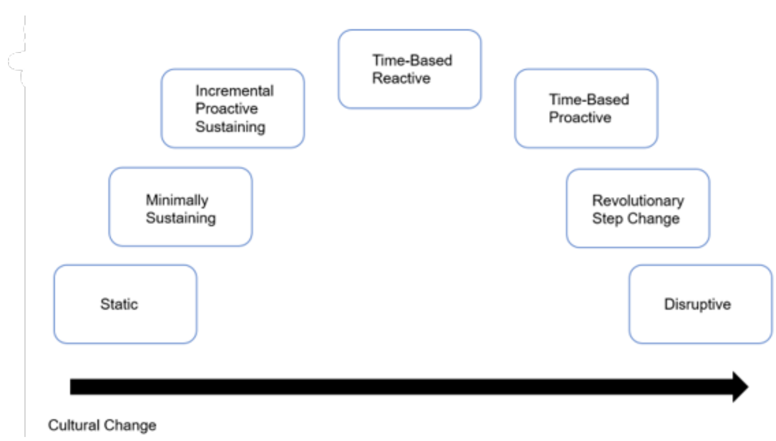

Figure 5. Typology of Innovation Strategies

Stasis and Decline

The first approach and one that is the foundation of this analysis is to start when innovation doesn't occur. No innovation is stasis and is the natural order of things. Stasis is the status quo and what elites and vested interests (be they labor or capitalists) are most comfortable with and often prefer. It is the foundation of world civilizations, order, and stability—except when it is not—and it is then the foundation of decline, disorder, and collapse. Advocates of stasis embark on policies to constrain changes wrought through innovation and advocates for greater innovation embark on policies to overcome the negative barriers put in place by those who favor the status quo.

While Figure 5 appears to outline innovation as a seemingly progressive order, the reality is that innovation, even in its non-disruptive forms, creates a backlash and a desire to return back to stasis. Innovation, thus, may better be described as a circle or cycle (Figure 6). What once were highly disruptive innovative capabilities eventually are absorbed into stasis and become the new status quo. These technologies or processes become entrenched, and then barriers are erected around them so as not to be disrupted by something else.

So, the cycle of innovation begins with stasis or the status quo. After all of the turmoil or disruption caused by something new, the system wants to revert back to a new status quo and put up its barriers and spines and protect itself against new innovation. In *The Technology Trap*, Carl Benedict Frey (2019) brilliantly describes this situation over history. Stasis is the political default choice for governments, dominant industrial firms, labor, and the financial community. The enablers of innovation become barriers. Processes and laws are created to limit and control innovation and maintain the status quo. The political and economic interests aligned against disruptive innovation often leads to decision gridlock and an embrace of what is current.

Labor wants to maintain its current jobs. Industry enjoys market dominance. Finance profits from this. In this environment, the question is why change? The problem is the longer stasis lasts, the greater the chance of such a system being disrupted, most likely from outside the domestic innovation system. U.S. industry after WWII, for example, was caught up in a stasis innovation period until the 1970s. Retooled during WWII by wartime expenditures and having most of its international competition destroyed in conflict, it could focus on existing products and meeting unmet consumer demand that built up during the war. It was not until Japan armed with Deming's incremental quality management tenants that American industry was disrupted.

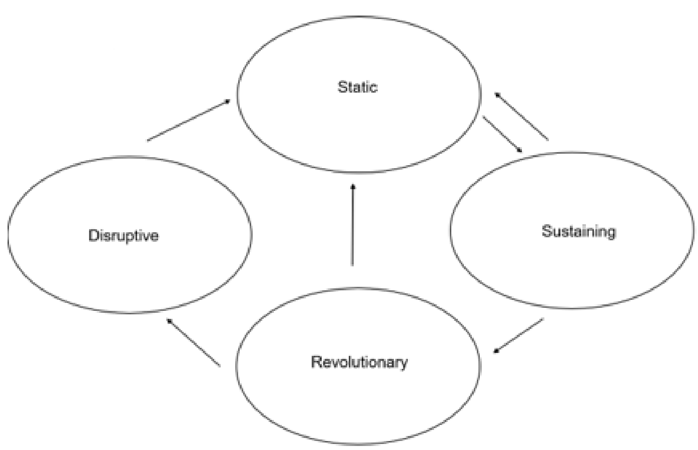

Figure 6. The Cycle of Innovation Types

Minimally Sustaining (Reactive)

Eventually stasis is no longer tenable. Market competition or international challenges begin to appear on the horizon that could threaten a company's market share or nation's security. Christenson (1997) describes the reaction to this situation as sustaining innovation or continuing to make only those improvements necessary to maintain market competitiveness. It requires no change to culture or operations and is the way a firm can continue to maximize its profits over the long term. In a national security context, this can be thought of as the minimum effort necessary to maintain the balance of power.

The first rung on the innovation ladder beyond stasis in this analysis is minimally sustaining. This is a reactive strategy used with a hope of doing as little as possible before moving quickly back to the old order. What is the least one could do to get by in addressing the competition? In the commercial world, that may involve a new marketing and pricing approach or the release of a limited new version of an old model. Cost cutting and personnel reductions are another minimally sustaining commercial strategy to shore up margins and the balance sheet. In defense, minimally sustaining approaches could manifest themselves in diplomacy, a reallocation or deployment of forces, and budget signaling—announcing increases in the defense budget or new programs designed more to deter than actually be executed. Perhaps a "commercial catch-up" effort can be pursued as well. FASA can be viewed in hindsight as primarily such a catch-up strategy when it became obvious that DoD had fallen behind the commercial market in information technology. Greater innovation from CMI through a more expansive interpretation of FASA's commercial item preference and the ability to modify those items could have been pursued. Instead, FASA implementation over the decades has focused on the mere adoption of COTS (or unmodified commercial off the shelf products) as the government did not really want to move much beyond the status quo.

Proactive Incremental Sustaining

In sustaining innovation, one can take a reactive or a proactive approach. Minimally sustaining is reactive. One is not yet disrupted, but competitive pressures are rising and an entity takes some reactive action. Another strategy is to address the prospects of that competition proactively. Ultimately, predictions about the future need to be made. A proactive incremental sustaining strategy is implemented though a future looking predictive planning process designed to do the minimum it requires to meet any perceived future threat to one's market or national security.

Whether this is a boardroom decision guided by a company's strategic planning process to allocate research and development (R&D) investment or DoD's PPBE, JCIDS and MDAP processes, a predictive and linear planned system is created to ensure that one does not spend too much money or resources on unnecessary innovation. This is a strategy that is implemented by market leaders who recognize the potential for competition on the horizon, but do not yet fear it. They only want to hedge against it.

While proactive incremental sustaining is a much better approach than reacting to market pressures, it is still drawn to a desire for a return to stasis. The whole process is considered somewhat wasteful in the sense that if only these bad new competitive actors would just leave us alone to our monopolies we could all live quietly and comfortably. But since we have to be on the watch for surprise, we will ensure that things are done right and rationally. This is a very incremental approach to innovation in both outlook and results. It is not limited by time but by process. We have all of the time in the world until we are truly disrupted (which cognitive dissonance suggest will never happen) so we need to take things step by step and slowly.

U.S. weapons procurement has primarily used a proactive incremental sustaining strategy since the establishment of the first 5000 series document in 1971. The incremental improvement of weapons systems initially designed in the 1970s has been the predominant focus of U.S. acquisition approaches toward the modernization of weapon systems for the last 50 years. Many of the same systems started during the Cold War are still the foundation of U.S. military forces—the Bradley Fighting Vehicle, M-1 Tank, Apache helicopter, F-15, F-16, and FA-18—albeit all incrementally upgraded. Ships, of course, have planned decades long lifetimes and receive incremental upgrades whenever they are in port for maintenance. For the last several decades, incremental upgrades—either through new contracted programs with the original contractor or conducted during depot maintenance of these items—have been the major source of defense innovation.

This is a minimalist strategy that corresponded to the lack of threats after the end of the Cold War and thus is a sustaining innovation strategy to maintain one's position in the market. Even new capabilities programs are usually planned incremental step changes from what came before. A proactive sustaining strategy has corresponded with a constraining oversight process focused on delivering capability to meet preordained estimated cost and technical goals. As has been continually learned, it is far easier to meet those goals if one limits risk—either technical or managerial.

The danger of pursuing a proactive sustaining strategy is that companies and governments can fool themselves through the planning process they are pursuing great advances in innovation. But in reality, they have created an extremely expensive strategy that primarily yields limited innovation productivity or rarely moves beyond the status quo. Those countries and firms that pursue innovation at a differing point in the innovation spectrum can potentially leapfrog the market leader who burdened with hubris and complicated processes could end up being left behind. There is a danger that a sustaining innovation strategy could continue in a national security context until these forces are finally tested on the battlefield and found wanting.

Time-Based Reactive

What does one do when one is already disrupted? Competition is not just on the horizon but is here and now bringing to bear something new that is threatening one's market, global or regional dominance. This dynamic can be seen in initial wartime innovation. If one is stuck in a process-based innovation strategy, the first thing to be done is to break the rules of the old system to rapidly meet any unexpected disruption. This has happened in every conflict in U.S. history: emergency acquisition authorities are put in place to buy and innovate at a faster scale where needs are immediate and time is of the essence (Nagle, 1999).

A time-based reactive strategy is different than a minimally sustaining reactive defense model. Innovation is driven by urgency. It is rapid and limited by time. Competition is no longer theoretical or emerging but is very real. A time-based emergency approach often generates new uses for modified existing technology. One might first need to use multi-million-dollar weapons to destroy drones that cost thousands. "Production Catch Up" or the ramping up of production of legacy weapon systems is initiated and then very quick capabilities programs are initiated to support combatant commanders in the field to address real shortcomings. The MRAP and counter-improvised explosive device (IED) programs of the mid-2000s using rapid acquisition authorities granted by Congress are prime examples of the more recent use of this type of innovation strategy.

Still, in the end, time-based reactive is limited by the desire to revert back to stasis. The widespread use of going around the existing system only lasts as long as the crisis and then is tossed aside. A sense of time and urgency will encourage new innovation to emerge but it is eventually incorporated back into either status or the predictive sustaining model.

Time-Based Proactive

Time-based strategies can also be proactive in anticipating future competition and disruption. This approach essentially uses artificial time constraints to drive advances in innovation. Rapid serial operational prototyping and rapid fielding as envisioned under Middle Tier Acquisition authority is one such proactive approach. A time-based proactive strategy can potentially be a revolutionary and disruptive model, but can also serve as a sustaining one. This approach is based on the time-based serial prototypes that were created by DoD in the 1950s, which evolved over several short cycles. Commercial equivalents were seen in the semiconductor industry's efforts to implement Moore's Law that drove 18-month advancements in integrated circuit design and production, as well as in agile software approaches used by Silicon Valley. Early Cold War–era weapons systems developments had an agile, time-fixed execution as depicted in Figure 7 by the history of the B-52. The B-52 could have foreshadowed a radically different future for U.S. defense acquisition, where DoD focused less on performance against prediction, and more on the speed of capability delivery and learning. DoD did not take that path, but Silicon Valley ultimately did. That the B-52 development looks remarkably like how Apple developed and produced the iPhone is not a coincidence.

Continuous quality improvement is the process-based analogue of serial operational prototyping. The Japanese auto industry's use of Deming's ideas and processes that centered on improving quality over time created significant quality changes in capabilities to the point that it completely disrupted the U.S. industry that had drifted into stasis. U.S. commercial industry began to adopt these ideas only after it was disrupted. A culture change was required in the factory and management around the concept of continuous process improvement, and ultimately the auto industry and much of the commercial manufacturing process was changed.

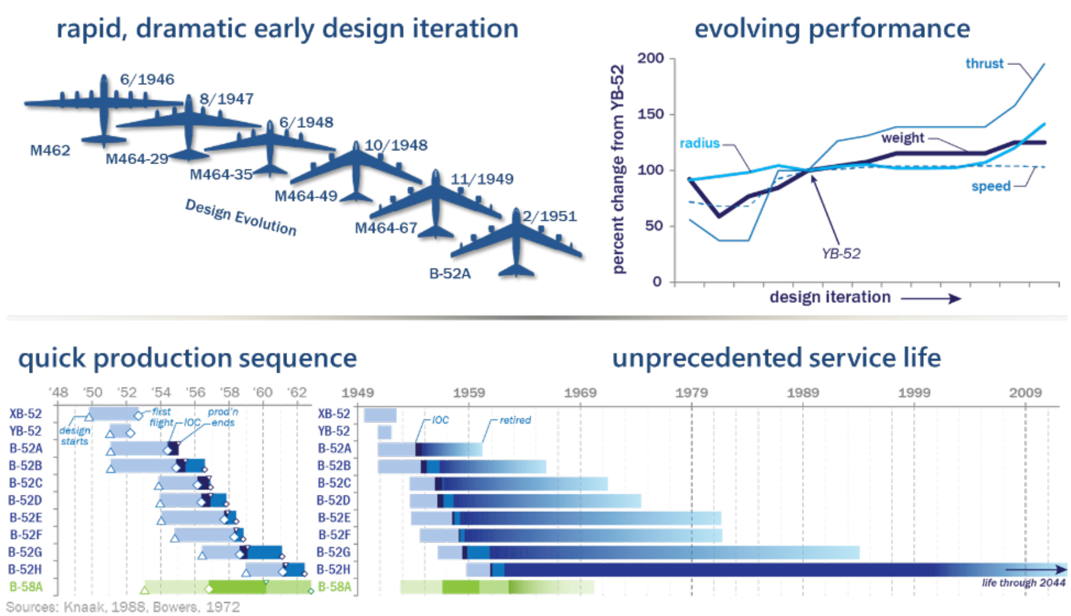

Figure 7. The B-52 and a Serial Operational Prototyping Strategy

Revolutionary Step Change

The concept of a revolutionary step change is introduced here to distinguish quality changes that perhaps don't qualify as disruptive. This is defined as a significant change in capability that may not be disruptive in the Christenson (1997) sense as it does not result in significant culture change, but is still a large jump in the quality of a capability. Revolutionary step changes in capabilities can occur through both predictive proactive sustaining and time-based methods, but will more likely to appear through a series of rapid time-based serial prototypes or serial changes in process.

One could have radical or revolutionary change within the sustaining innovation category. It is often difficult to do so because achieving such a significant step change in technological innovation is achieved almost by accident because originally a proactive sustaining approach was only designed to incrementally maintain one's place in the marketplace. It is possible for predictive models to actually get it right and be revolutionary by pushing the bounds of technology in 10-20 years' time. Ironically, that may have come from initial inaccurate perceptions of the evolving threat. Even if a predictive program does achieve such an outcome, it will likely not do so in accordance with its original predicted baselines of cost, schedule, or performance, as after a few years the adequacy of those predictions become increasingly deficient. Thus, if a new technology is delivered a decade or so later it is often seen as a failure despite some having achieved revolutionary step changes in capability.

Emergency reactive time-based approaches can also result in revolutionary innovation. A step change in military innovation occurred in intelligence, surveillance, data analytics, and sensor fusion to address post 9/11 national security threats designed to track down small independent combatant units in Afghanistan, Iraq, and Syria. These new innovative efforts were examples of how to enable near-term technological advantage on the battlefield, but they would not have likely been made except for urgent operational shortcomings. These are revolutionary in the sense that they while technologically significant did not require a significant change in culture or operations to incorporate and provided further battlefield advantage.

Most of the discussion up to this point has been about the United States as market leader both in commercial and defense. What if you are not a market leader and want to be the disrupter? The flip side of a sustainment innovation strategy is first catching up. This begins with a greenfield catch-up strategy that takes advantage of the state of the art made possible by the global diffusion of technology and knowledge. Greenfield catch up is what first Japan, China, the ASEAN nations, and now India have been doing for decades. The creation of a new facility, factory, or business can begin with the state of the art at the time of initiation. This can incorporate all of the lessons learned in producing past capabilities and can also consider new emerging approach to innovation in creating that capability to catch up. Disruption can then happen through a leap frog approach that once the new greenfield operation has been established can take advantage of time base innovation strategies. China's remarkable pace in military hardware appears to conform with this strategy (Greenwalt & Patt, 2021).

Disruption

Disruptive innovation up ends markets and balances of power. It not only requires a major technological or market offering change, but a change in culture and operations or business model. In Christenson's (1997) commercial analysis, this results in an easier to use, cheaper alternative that is more accessible and available to a larger population. This is likely not to come from the incumbent, who is more focused on sustaining innovation. In business, disruptive innovation comes from finding a cheaper way of doing things, which has not always been the case in the defense market. Disruption in this context comes from doing something faster, better, or cheaper and by doing so is so revolutionary that it forces all sides to change how they think about the market.

While disruptive innovation can change the market and culture or operations, the Christenson (1997) framework needs to be modified for defense. This would address a truly radical new revolutionary technology or capability to emerge, which is likely to be less accessible and perhaps more expensive than other alternatives, at least initially. The submarine, tank, aircraft carrier, nuclear weapons, and satellites were disruptive innovation candidates as defined by the need to change culture, but they do not meet the rest of the Innovator's Dilemma definition.

There are two types of disruption to consider. One is an order of magnitude better, faster, and cheaper capability than the existing solution. One area in defense that might qualify is the proliferation of cheap, unmanned drone development that has arisen in the Ukraine war and the Middle East. Asymmetric strategies such as cyber warfare, disinformation, and anti-access/area denial strategies may be cases of revolutionary innovation, but could also meet Christenson's disruptive criteria of cheaper, more accessible innovation likely to be initiated from outside the dominant culture.

A second disrupter is the never been done before moonshot that actually succeeds. These disruptive defense capabilities require a significant shift in outlook, process, tactics, and doctrine. They are not always cheaper, easier to use, or more accessible, but they change the rules of the game completely. There are two methods to achieve disruption, which are both predominantly time-based. The first is the adoption of the ruthlessness of the venture capital power law incentives, and the second is the development of government-sponsored revolutionary operational prototypes.

VC Power Law Model

The venture capital (VC) power law as outline by Sebastian Mallaby (2022) is a situation in the venture capital market where only a small number of investments are successful while the majority fail. These successful investments need to provide something like a 10X return to cover those other failed investments. To get that type of return, one needs to disrupt the existing market through major improvements in productivity at a fraction of the cost, develop something new that has never been done before, or both. This is what SpaceX did with its Falcon 9 and why it is a prime example of the ability of the VC power law model to drive disruptive innovation. Falcon 9 was developed for a tenth of the cost that NASA originally estimated it would cost if conducted under the traditional proactive incremental predictive model. It also ultimately delivered a more than a 10X gain in productivity as measured by the cost to launch a pound to space and it did it by doing something new—reusing bits of the launcher. Achieving this has completely disrupted the space market and is leading to other new advances in commercial satellite networks and distribution. This disruption fits neatly into Christenson's (1997) framework as doing something better and cheaper that changed the space culture and made it accessible to more people, but the VC model could equally be leveraged for the second method.

Time-Based Disruptive (Moon Shots)

As much as the private sector can be innovative and disruptive, some things can be too big or too risky for the private sector to do alone. Even the Falcon 9 was developed using NASA money. There is a reason these types of efforts are called moon shots, but the model that took America to the moon was refined in the 1950s and early 1960s in defense. It was during this time that DoD deployed the first nuclear power ships and submarines, the first jet aircraft, the first ICBM, the U-2, SR-71, and the first reconnaissance satellites. These efforts were time driven and for the most part took less than 5 years to deploy something that was operationally capable and usable. The Apollo program may be the best example of a “moon shot” but these efforts were designed to disrupt or revolutionize their environment. They each required a different way of thinking about the future.

This different way of thinking evolved from the early Cold War competition with the Soviet Union that incentivized the U.S. military to maintain World War II development emphases. This resulted in the creation of multiple disruptive new technologies. Innovation efforts conducted during the war, in the 1950s, and then in the subsequent space race with the Soviet Union in the 1960s had several things in common: a focus on time, rapid experimentation, multiple technological pathways, rapid operational prototyping, and a risk-taking culture that embraced creating something new and disruptive.

Disruptive innovation may be closer to the technological component that supports the concept of the Revolution in Military Affairs doctrine from the 1970s that originated in the Soviet Union and was the source of much interest in the United States after the Gulf War by Andrew Marshall in the Office of Net Assessment (Dombrowski & Ross, 2008). Future disruptive innovation in this context could potentially cover the potential use of artificial intelligence linked to autonomous systems or in the deployment of directed energy weapons. The current National Missile Defense system was essentially and still is an operational prototype. A U.S. Golden Dome would likely start out similarly and end up being highly disruptive if successful.

Conclusion: U.S. Defense Innovation Since WWII

Using this taxonomy, the history of U.S. innovation efforts can be assessed (see Figure 8). At some point in time, the United States has pursued or taken advantage of each of the innovation models, categories, and types. Unfortunately, there has been a marked tendency to creep back toward stasis and the status quo with corresponding countervailing efforts at using a predictive and process based sustaining innovation. To compete in the newly emerging global threat environment, DoD needs to pursue more disruptive, time-based defense innovations similar to the innovation pathways it pursued in WWII and the early Cold War.

The post-World War II period was a watershed moment for U.S. defense innovation. It didn’t have to be that way and could have very easily conformed to the pre-World War II pattern. Whether through serendipity, planning, luck, or foresight, the past cycle was broken, and the system did not return to stasis after the conflict. This period did not last long—at most 20 years—but it became the most innovative period in U.S. history and the source of some of the most significant military technologies still in use today.

The 1960s becoming a transition decade. In the aftermath of the Cuban Missile Crisis and the rise of arms control measures to try and manage conflict, military innovation entered a stasis period with a planned proactive incremental sustaining strategy adopted as a hedge against technological breakthroughs from the Soviet Union. The end of the Cold War saw even this sustaining strategy rolled back significantly. The Global War on Terrorism encouraged some emergency time-based reactive measures that were reversed once the conflicts in Iraq and Afghanistan ended. Sustainment type innovation strategies and U.S. dominance began to be tested in 2014 by the invasion of Crimea and Chinese militarization of disputed islands in the South China Sea. Congress reacted by providing the means to adopt a time-based disruptive innovation strategy through the expansion of Other Transaction production and rapid acquisition authorities, the strengthening of the commercial item preference, the establishment of Middle Tier Acquisition authority, and the creation of the software acquisition pathway. The last decade has only seen marginal usages of these authorities and little disruption.

Time Period	US Innovation Trends and Types
World War II	Defense: Emergency Time-Based Reactive, Time-Based Disruptive Commercial: CMI to Defense, Subsidized Retooling
Early Cold War (1945-1960)	Defense: Serial Time-Based Operational Prototype Disruptive Commercial: Innovation Statis, Sales Expansion to Meet Pent-up Demand
Late Cold War (1960-1990)	Defense: Beginning of Arms Control Statis and Minimally Sustaining Proactive Model Industrial Commercial: Statis and Decline then Emergency Time Based Reactive Once Disrupted Japan Challenge (1970s Proactive Quality Process) Emergency Reactive Silicon Valley: CMI from Defense, Serial Time Based Disruptive (Moore's Law)
Post-Cold War Pax USA (1990-2014)	Defense: Stasis (Peace Dividend), Minimally Sustaining Predictive GWOT: Emergency Reactive (MRAP/RAA) Industrial Commercial: Minimally Sustaining -- China Outsourcing Strategy Silicon Valley: Serial Time Based + VC Disruptive
US Hegemony Challenged (2014-2025)	Defense: Stasis and Expanded Evolutionary Predictive Creation of Time Based and Disruptive Alternatives (Production OTA/MTA/Software Pathway) Industrial Commercial: Emergency Reactive, Supply Chain Disruption, China Risk Reduction and Decoupling (Friend-shoring, Insourcing) Silicon Valley: Serial Time Based + VC Disruptive

Figure 8. History of U.S. Innovation Efforts

Defense innovation in the United States continues to primarily focus on predictive, process based, incremental sustaining innovation. To compete in a new Great Power competition, defense innovation needs to become more time based and disruptive, taking advantage of growing trends in the commercial innovation system through CMI. This will require a change in culture, mindset, and processes. The ingrained cultural resistance to disruptive new technologies and ways of doing business has to be addressed to achieve any traction on achieving the necessary changes to the industrial base and management regimes required to enable future disruptive and revolutionary step change defense innovation.

References

Christensen, C. M. (1997). *The innovator's dilemma: When new technologies cause great firms to fail*. Harvard Business School Press.

Collins, J. (2001). *Good to great: Why some companies make the leap ... and others don't* (1st ed.). Harper Business.

Dombrowski, P., & Ross, A. L. (2008). The revolution in military affairs, transformation and the defense industry. *Security Challenges*, *4*(4), 13–38.

Drucker, P. (1985). *Innovation and entrepreneurship: Practice and principles* (1st ed.). Harper and Row.

The Economist. (2025, February 13). America's military supremacy is in jeopardy. (2025, February 13). https://www.economist.com/briefing/2025/02/13/americas-military-supremacy-is-in-jeopardy

Frey, C. B. (2019). *The technology trap: Capital, labor, and power in the age of automation*. Princeton University Press.

Gertner, J. (2012). *The idea factory: Bell Labs and the great age of American innovation*. Penguin Press.

Gordon, R. J. (2012). *Is U.S. economic growth over? Faltering innovation confronts the six headwinds*. National Bureau of Economic Research. https://doi.org/10.3386/w18315

Greenwalt, W., & Corbin, T. (2023). *Breaking the barriers: Reforming U.S. export controls to realize the potential of AUKUS*. United States Studies Centre. https://www.ussc.edu.au/breaking-the-barriers-reforming-us-export-controls-to-realise-the-potential-of-aukus.

Greenwalt, W., & Corbin, T. (2024, August 29). *AUKUS enablers? Assessing defence trade control reforms in Australia and the United States*. United States Studies Centre. https://www.ussc.edu.au/aukus-assessing-defence-trade-control-reforms-in-australia-and-the-united-states

Greenwalt, W., & Patt, D. (2021, February 25). *Competing in time: Ensuring capability advantage and mission success through adaptable resource allocation*. https://www.hudson.org/national-security-defense/competing-in-time-ensuring-capability-advantage-and-mission-success-through-adaptable-resource-allocation

Greenwalt, W., & Patt, D. (2025, March 25). *Required to fail: Beyond documents: Accelerating joint advantage through direct resourcing and experimentation*. Hudson Institute. https://www.hudson.org/technology/required-fail-beyond-documents-accelerating-joint-advantage-through-direct-resourcing-dan-patt-william-greenwalt

Hall, B. H., Rosenberg, N., & Mowery, D. (2010). Military R&D and innovation [Essay]. In *Handbook of the Economics of Innovation. Volume 2* (pp. 1219–1256). Elsevier.

Hindle, B., & Lubar, S. D. (1986). *Engines of change: The American Industrial Revolution, 1790–1860*. Smithsonian Institution Press.

Howard, R. A. (1978). Interchangeable Parts Reexamined: The private sector of the American arms industry on the eve of the Civil War. *Technology and Culture*, *19*(4), 633–649. https://doi.org/10.2307/3103762

Kim, W. C., & Mauborgne, R. (2005). *Blue ocean strategy: How to create uncontested market space and make the competition irrelevant*. Harvard Business School Press.

Mallaby, S. (2022). *The power law: Venture capital and the making of the new future*. Penguin Press.

Madhavan, G. (2015). *Applied minds: How engineers think*. W.W. Norton & Company.

Nagle, J. F. (1999). *A history of government contracting* (2nd ed.). George Washington University Press.

Raber, M. S., Malone, P. M., Gordon, R. B., & Cooper, C. C. (2009). *Forge of innovation: An industrial history of the Springfield Armory, 1794–1968*. Eastern National.

Thiel, P. (2014). *Zero to one: Notes on startups, or how to build the future*. The Crown Publishing Group.

Wilson, J. Q. (1989). *Bureaucracy: What government agencies do and why they do it*. Basic Books.

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