US Defense Industrial Base: Strong, but at Risk

A Monograph

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The Defense Industrial Base (DIB) is a combination of both government and commercial organizations that produces military munitions and equipment. Since the successful surge of US defense industrial might in World War II, the DIB has been slowly eroding. During this slow decline over the past seventy-five years, some critical vulnerabilities have emerged in the DIB. Three of these vulnerabilities in the DIB are: sole sources of production for military equipment and ammunition, decreased funding for infrastructure maintenance and modernization, and reliance on foreign sources for key components and chemical compounds. These vulnerabilities increase the risk of not being able to meet potential surge requirements generated by a future high-intensity conflict with a peer adversary.

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Abstract

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The Defense Industrial Base (DIB) is a combination of both government and commercial organizations that produces military munitions and equipment. Since the successful surge of US defense industrial might in World War II, the DIB has been slowly eroding. During this slow decline over the past seventy-five years, some critical vulnerabilities have emerged in the DIB.

Three of these vulnerabilities in the DIB are: sole sources of production for military equipment and ammunition, decreased funding for infrastructure maintenance and modernization, and reliance on foreign sources for key components and chemical compounds. These vulnerabilities increase the risk of not being able to meet potential surge requirements generated by a future high-intensity conflict with a peer adversary.

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Acronyms

AAP	Army Ammunition Plant
AWCF	Army Working Capital Fund
ASL&T	Army Under Secretary for Logistics and Technology
CAAA	Crane Army Ammunition Activity
DASA	Deputy Assistant Secretary of the Army
DIB	Defense Industrial Base
DOD	Department of Defense
GOCO	Government-Owned Contractor Operated
GOGO	Government-Owned Government Operated
IMCOM	Installation Management Command
LCAAP	Lake City Army Ammunition Plant
RAAP	Radford Army Ammunition Plant
TACOM	Tank and Automotive Command
WCF	Working Capital Fund

Introduction

The Defense Industrial Base is a national insurance policy.

—General (R) Dennis Via, former commander, Army Materiel Command

Powerful enemies must be out-fought and out-produced.

—President Franklin Roosevelt

Just after the Japanese attack on Pearl Harbor in December, 1941, many senior Japanese leaders celebrated their surprise victory against America but at the same time feared the industrial and military potential of the United States.[1] They knew that the defense industrial base (DIB) of the United States was a strategic strength, and a great capability to build combat power in both theaters of World War II.[2] Would that same concern or fear be in the back of an adversary's mind today in a similar scenario?

The current day defense industrial base is a complex system of both government- owned and commercial production, storage, and distribution facilities. The term DIB was formally recognized, as the name that described both the government and commercial defense industries, in the late 1930s. In 1794, Congress granted President George Washington the authority to establish a national arsenal to arm the Army of the United States with domestically-produced weapons and ammunition.[3] Then, in 1853, Congress granted the Secretary of War the authority to close or abolish any depot or arsenal that they thought was no longer needed. Furthermore, during the height of the Industrial Revolution, Congress mandated that the Department of the Army procure supplies and weapons from government-owned and operated facilities if

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[1] Eric M. Bergerud, *Fire in the Sky: The Air War in the South Pacific* (Westview Press, 2000), 225-227.

[2] Ibid., 229.

[3] Daniel H. Else, *The Arsenal Act: Context and Legislative History* (Washington, DC: Congressional Research Service, 2011),14, accessed November 11, 2017, https://digital.library.unt.edu/ark:/67531/metadc83994.

economically feasible. This defense equipment procurement guidance was written in both the 1853 and 1920 versions of US Code, and is commonly referred to as "the Arsenal Act of 1920."[4] The Arsenal Act of 1920 also provided the foundations on which the current DIB is built and governs how productions operations on the government side are executed.[5]

The government-owned portion of the United States DIB, or what is referred to as the "organic base," has actually been in existence for well over two-hundred years and has expanded, contracted, modernized, and been reconfigured many times to support national strategic requirements. The organic base is operated, funded, and modernized as one of the Department of Defenses' core activities, and governed by a series of legislative provisions beginning with the Arsenal Act of 1920.[6] In a somewhat similar fashion the civilian defense equipment industry is deeply rooted in American society and the national economic landscape and has supported military operations with ammunition, equipment, and new technology much like the governmental entities.

Since the successful surge of the US defense industrial base in World War II, the government and civilian defense industrial base has been slowly eroding. Also, America's dominance of military power is now challenged by nations like Russia and China along with the emerging nuclear threats from North Korea and Iran.[7] What are some of the critical vulnerabilities in the US defense industrial base, and how have they emerged over the past

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[4] US Arsenal Act of 1920, US Code 10 (2001), §§4532 et seq.

[5] Daniel H. Else, *The Arsenal Act: Context and Legislative History* (Washington, DC: Congressional Research Service, 2011),12-14, accessed November 11, 2017, https://digital.library.unt.edu/ark:/67531/metadc83994.

[6] Ibid., 15.

[7] The President of the United States, *National Security Strategy of the United States of America* (Washington, DC: The White House, 2017), accessed 22 January, 2018, https://www.whitehouse.gov/articles/new-national-security-strategy-new-era/.

seventy-five years? The vulnerabilities in the DIB increase the risk of not being able to meet potential surge requirements generated by a future high-intensity conflict with a peer adversary.[8]

This monograph will examine three key vulnerabilities in the DIB that increase the risk that the DIB cannot meet requirements: sole sources of production for military equipment and ammunition, decreased funding for infrastructure maintenance and modernization, and foreign sources for key components and chemical compounds. The argument presented in this monograph will examine each of these vulnerabilities and discuss the associated risk to military readiness and power projection for the US military.

This monograph will start with a brief historical summary of the development of the DIB. The purpose of the history up front will be to describe the evolution of the economic and political environment during the Industrial Revolution and leading up to the US involvement in both World War I and World War II. The monograph will specifically consider the early 1940s in order to draw a comparison to better illustrate the changes to, and subsequent erosion of, the combined defense industrial capability from 1950 to the present. This monograph will discuss the creation of single points of failure in the defense industrial base due to sole sourcing, the flawed funding strategies for the DOD portion of the DIB, and the fact that the DIB relies on foreign sources for some key chemicals components of munitions. In conclusion, the monograph will propose some mitigation actions related to the three vulnerabilities that national leaders should consider in order to ensure that the DIB is better postured to meet potential future demands. Additionally, the monograph will offer some perspectives related to the effects of the changing US economic landscape and global power balance that should be examined further in follow-on research concerning the defense industrial base.

[8] Brandon L. Grubbs, "Does the Defense Industrial Base Environment Create Strategic Risk?" (monograph, US Army War College, 2013), 8, accessed October 23, 2017, http://www.dtic.mil/docs/citations/ADA589330.

Defense Industrial Base History

When examining the last 75 years of the DIB's historical background, the gold standard of US success with the DIB was the massive industrial surge that took place in support of World War II. Some strengths of this combined effort were the vast and diverse capabilities of both the government and commercial industries that worked closely to produce massive outputs. The growing commercial auto industry, easily adapted assembly lines, and massive government investment in building infrastructure increased output capability. Also, a large group of engineers existed in the DIB and they were able to quickly train both government and commercial workers, in order to rapidly adapt production from peace time goods to tanks and aircraft.

This combined effort was fueled by a domestically based industrial surge and new research stemming from a wave of technological innovations that started at the turn of the twentieth century.[9] The United States used these relatively new, commercial industrial capabilities, paired with the large government investment in defense manufacturing infrastructure and distribution capability, to produce huge amounts of armaments and critical combat equipment in about two years' time. This robust capability surge gave the United States the competitive edge in both the Pacific and European theaters and enabled the rapid equipping of the allied forces that defeated multiple adversaries in a large-scale high-intensity conflict. [10] The vast economic power and growth of the United States in the mid-twentieth century created the environment for the creation of a DIB like the world had never seen and also provided a

[9] Barry D. Watts, *The US Defense Industrial Base: Past, Present, Future* (Washington, DC: Center for Strategy and Budgetary Assessments, 2012), 12, accessed October 17, 2017, http://www.dtic.mil/docs/citations/ADA506796.

[10] William H. Chafe, *The Unfinished Journey: America Since World War II* (Oxford England: Oxford University Press, 2003), 4.

significant advantage for the United States in terms of superior military force readiness and the ability to project military might globally.[11]

Often lessons are simply observed, yet not truly learned. The unfortunate tendency to ignore the lessons of the past is that our leaders accept a much higher risk of failing or not being prepared for future situations. In order to support the argument that the DIB is more vulnerable, the history that contributed to the emergence of critical vulnerabilities must be examined. In the next few pages the history of the DIB will be presented focusing on the pre-World War II build-up to present day. A key takeaway from this historical look is that the capacity and capabilities of the DIB have slowly but steadily eroded over the past seventy-five years. Additionally, this historical background provides required context focused on the historical decisions that caused the slow degradation of capabilities over time and subsequently created the vulnerabilities that are being examined by this monograph.

In 1914, as the world entered into World War I, more American manufactures were lobbying Congress to partner with the DOD industrial complex to produce the weaponry that would be required by American allies in Europe, but Congress held fast to the 1853 provision of the Arsenal Act that provided that items would be produced by government-owned industrial facilities, and only when the full capacity of the government facilities were reached could a civilian company start to make those same items.[12] This constraint was a clear example of policy impeding maximization of outputs. Additionally, the late entry of US forces into World War I resulted in a delayed decision to increase production capability in the DOD portion of the DIB. Therefore, after WWI, the United States had not greatly expanded its organic or commercial

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[11] Jacques S. Gansler, *Democracy's Arsenal: Creating a Twenty-First-Century Defense Industry* (Cambridge, MA: The MIT Press, 2011), 21.

[12] Daniel H. Else, *The Arsenal Act: Context and Legislative History* (Washington, DC: Congressional Research Service, 2011), 8, accessed November 11, 2017, https://digital.library.unt.edu/ark:/67531/metadc83994.

defense industry capability. This missed opportunity to posture the DIB to be rapidly responsive resulted in a slow initial production output when war broke out again in Europe in1936 and thus the United States was not fully prepared. Even though the DIB was on its heels in the mid-1930s, the US recovery from the great depression, along with US industrial growth in the late 1930s, created a foundation for the government and commercial defense industry in the United States to execute a surge in support of World War II.[13]

World War II (1938-1945)

From 1937-1945, the DIB grew, first to meet the wartime demands of allied forces, and then US needs when the United States entered the war in 1941.[14] The rapid output of military equipment was one of the most significant accomplishments of the US support to the war effort. From 1940-1943, as the US forces grew to over 8 million soldiers, the industrial base consisting of both DOD and commercial partnerships built 96,000 tanks, produced over seventy-eight billion rounds of small arms ammunition, and produced over 7 million tons of aircraft bombs.[15]

However, the only way that these staggering outputs were even possible was because the DOD organic industrial base partnered with civilian industry to maximize overall outputs. One of the key new partnerships that came from this build-up period was the government-owned contractor operated (GOCO) ammunition and equipment manufacturing plants.[16] The GOCO business model used government land, infrastructure, and equipment and a civilian company or

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[13] Ibid.

[14] Brandon L. Grubbs, "Does the Defense Industrial Base Environment Create Strategic Risk?" (monograph, US Army War College, 2013), 8, accessed October 23, 2017, http://www.dtic.mil/docs/citations/ADA589330.

[15] Alan L. Gropman, *Mobilizing US Industry in World War II* (Washington, DC: Institute for Strategic Studies, National Defense University, 1996), 104.

[16] Brandon L. Grubbs, "Does the Defense Industrial Base Environment Create Strategic Risk?" (monograph, US Army War College, 2013), 11, accessed October 23, 2017, http://www.dtic.mil/docs/citations/ADA589330.

conglomerate of companies to run the operations, under a government contract.[17] This model facilitated the training of civilian skilled labor by DOD experts and also provided larger amounts of financial capital by combining government and commercial means. The commercial partners could innovate rapidly and develop new concepts using government-funded facilities and equipment, resulting in a very flexible and responsive surge capacity. Additionally, the DOD benefited by retaining the intellectual capital created in these partnerships and was able to rapidly build knowledge of these processes and systems across the DIB.

In support of World War II, the government built seventy-seven GOCO production facilities in twenty-four different states. The facilities were charged with producing small-caliber ammunition, mortars, artillery rounds, propellants, explosives, bombs, and extruded aluminum for aircraft production.[18] As result of a massive government construction initiative and funding effort, the GOCO plants were all built in a two-year period and, along with the already operational GOGO facilities, formed the "organic DIB." At the end of World War II, the organic DIB consisted of over 115 depots, manufacturing plants, and arsenals in over thirty-four states.[19] More broadly, this organic base, along with the vastly expanded commercial industrial base, gave the United States the important strategic capability to produce weapons and ammunition in order to respond rapidly to large-scale wartime demand. This also marked the first time in US history where the name "Defense Industrial Base" was used to describe the collective government and commercial defense sectors as a whole.[20]

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[17] Ibid.

[18] Gary A. Martin, "Defense Industrial Base (DIB): Munitions Realignment for 2020" (monograph, US Army War College, 2013), 10, accessed November, 18 2017. http://www.dtic.mil/docs/citations/ADA589420.

[19] Ibid., 13.

[20] Ibid., 15.

Post-World War II (1965)

Immediately following WWII, the US defense industrial base was the largest it had ever been and the largest to date in US history. However, in the period from late 1945 until the mid-1960's, the focus and priorities changed dramatically. The nuclear age of weapons, along with the US national strategy of deterrence, created a new focus and priority for the capabilities of the defense industrial base. The focus shifted from conventional weapons and ammunition production to building and stockpiling the nuclear and chemical arsenals in response to the Cold War with the Soviet Union.[21] Many production facilities were modernized and retooled to make components of modern conventional and nuclear weapons and some were even converted to fill and package chemical munitions.[22] Modernization drove the decision to reduce the size of the DIB, and thus resulted in the closure of some GOCO plants. However, as production capability was reduced, the arms race between the United States and the Soviet Union did create a greater requirement for storage depots. These large storage and repair facilities now had the requirement to store nuclear and chemical rounds along with the conventional ammunition. The demand for additional, specialized, and highly secured storage space required a large investment by both the federal government and some emerging defense contractors.

Changes like these masked the emergence of vulnerabilities in the production capacity of the DIB.[23] The vulnerabilities were masked because, in the aggregate, the DIB did grow slightly during the early 1950s by adding additional storage space and maintenance buildings for nuclear warheads, but the overall production capability was cut. These production cuts were the start of a

[21] Ibid., 17.

[22] Ibid.

[23] Barry D. Watts, *The US Defense Industrial Base: Past, Present, Future* (Washington, DC: Center for Strategy and Budgetary Assessments, 2012), 19, accessed October 17, 2017, http://www.dtic.mil/docs/citations/ADA506796.

trend of cuts in this sector that eventually led to a single source of production for certain key items.

Advocates for the production facility cuts argued for the benefits of reduced operating cost and the ability to divert monies to build a larger nuclear arsenal in order to deter Soviet aggression.[24] However, a second-order effect of the cutbacks in the number of government production facilities was that civilian industry controlled a greater portion of the manufacturing and thus controlled the cost of production. Because the commercial industry must profit to survive and there were a limited number of companies that could perform this work, the cost rose to extremely high levels.[25] But the arms race continued to push demand higher as the United States and Soviet Union built their new nuclear arsenals. The increasingly high demand for the items coupled with the limited number of manufacturers drove the profit potential to very high levels. Companies started to see enormous financial potential in producing armaments and defense-related items for the federal government.[26] These commercial companies formed strong political lobbies and pressured Congress to direct work to them rather than maintain government-owned facilities. The result of this again was a slow chipping away of the DIB's overall footprint and subsequent surge capacity.

In past conflicts, armament modernization was often driven by a change in the conduct of warfare, or in a few cases, a new weapon technology changed the nature of war and how wars were fought. Arguably, the nuclear bomb changed the conduct of war more drastically than any other advancement. An effect of this nuclear advancement in warfare was the economic dynamic that was created in the United States and some other advanced western nations. The number of

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[24] Jacques S. Gansler, *Democracy's Arsenal: Creating a Twenty-First-Century Defense Industry* (Cambridge, MA: The MIT Press, 2011), 28.

[25] Ibid.

[26] Ibid., 30.

lucrative government defense contracts grew at unprecedented rates, further adding to the problem mentioned in the previous paragraph.[27] Many new startup businesses began hiring engineers and scientists from top universities to develop new and more capable weapons systems that they would convince the government to buy. A new economic boom was emerging, not for consumer goods, but for weapons.

This rapid growth, coupled with the growing influence of these commercial defense firms on local and national political leaders, concerned many.[28] One of the most concerned was the president of the United States at the time, Dwight Eisenhower. In a farewell speech to the nation in 1961, Eisenhower warned that a strong defense was necessary to deter American adversaries, but a new threat was emerging on the home front. That threat was the growing size and influence of the defense industrial base. Eisenhower warned that an uncontrolled buildup of weapons and giving too much financial and political power to defense companies and contractors could have negative long-term effects on the American economy and could corrupt Washington, DC even further.[29] As the 1960s got underway and Eisenhower left office, new threats and situations around the globe would affect the United States' utilization and posture of the defense industrial base.

Cold War (1960-1990)

In the early 1960s, the largest perceived threat to the United States was the spread of communism and the continued growth of the Soviet nuclear arsenal. With the continued growth of the nuclear arsenal, the DIB adapted to produce nuclear and chemical munitions, while still

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[27] Jacques S. Gansler, *Democracy's Arsenal: Creating a Twenty-First-Century Defense Industry* (Cambridge, MA: The MIT Press, 2011), 32-33.

[28] Susan Eisenhower, "50 Years Later We're Still Ignoring Ike's Warning," *Washington Post*, January 16, 2011, accessed 19 January, 2018, http://www.washingtonpost.com/wp-dyn/content/article/2011/01/14/AR2011011404915.html.

[29] Ibid.

producing much smaller numbers of conventional weapons and munitions.[30] However, on top of the threat of the Soviet Union in the late 1950s to early 1960s was another emerging enemy. The potential spread of communism in southeast Asia presented a new problem. The most notable threats at this time were in Korea and Vietnam (Indochina). During the Cold War with Russia, the United States was involved in smaller-scale, high-intensity military conflicts in Korea in the 1950s, and in the early 1960s the United States placed 10,000 military and civilian advisors in South Vietnam to advise the South Vietnamese on how to defeat a growing threat from communist factions.[31] With combat forces committed in Vietnam in 1965 the demand for conventional ammunition temporarily increased. This short surge demand for conventional ammunition impacted the defense industrial base and for a three- year period production surged. Even though government-owned manufacturing plants had not produced at full capacity since late 1945, they were still relatively new and modern for the day. The ramp up in support of Korea and Vietnam happened very rapidly and with minimal new infrastructure investments other than hiring back a larger work force, that in many cases, had worked in the industry in the mid-1940s. With a focus on increased production to meet demand, the DIB produced 62 billion rounds of small caliber ammunition and 155,000 tons of aircraft bombs, all while growing the nuclear arsenal and increasing the aircraft fleet for the US Airforce.[32]

After the end of US involvement in Vietnam and a lack of political support for military spending, DOD budgets were reduced. As a result of these budget cuts, in the mid-1970s and

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[30] Jacques S. Gansler, *Democracy's Arsenal: Creating a Twenty-First-Century Defense Industry* (Cambridge, MA: The MIT Press, 2011), 32.

[31] Robert D. Kaplan, *Asia's Cauldron: The South China Sea and the End of a Stable Pacific* (New York, NY: Random House, 2014), 145.

[32] Christopher J. Tassava, "The American Economy during World War II," EH.Net Encyclopedia, edited by Robert Whaples, February 10, 2008, accessed March 22, 2018, https://eh.net/encyclopedia/the-american-economy-during-world-war-ii/.

early1980s the government portion of the DIB was reduced in size.[33] For example, in the government-owned portion of the DIB the number of (GOCO) facilities dropped from seventy-seven to twenty-five, an almost two-thirds cut in that sector alone.[34] The number of GOGO maintenance depots was cut from twenty-five to ten, a sixty percent cut.[35] With the downsizing of the military forces and the smaller budgets from Congress for defense spending, many private sector businesses either left the industry, merged with larger companies, or in a few cases went out of business completely. A steady decline of the entire defense industrial base took place from 1973-1990 and set a course of slow erosion of the DIB.[36]

Post-Cold War (1991-2000)

In the early 1990s, with the end of the Cold War, the defense budgets took even deeper cuts as the nation and the military assessed the threats in the post-Cold War world.[37] The late 1980s and early 1990s saw four rounds of base realignments and closures (BRAC) in the Department of Defense in the years 1988, 1991, 1993, 1995.[38] These cuts in base footprint saved money in the near term and consolidated the larger footprints of many services into more manageable pieces, but the impact on the DIB was not a priority and therefore was not addressed. The impact of this series of BRAC closings on the DIB is still felt today and has directly contributed to a single source of production vulnerability trend that currently exists

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[33] Barry D. Watts, *The US Defense Industrial Base: Past, Present, Future* (Washington, DC: Center for Strategy and Budgetary Assessments, 2012), 22, accessed October 17, 2017, http://www.dtic.mil/docs/citations/ADA506796.

[34] Ibid., 23

[35] Ibid.

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[36] Ibid.

[37] Jacques S. Gansler, *Democracy's Arsenal: Creating a Twenty-First-Century Defense Industry* (Cambridge, MA: The MIT Press, 2011), 39.

[38] Jacques S. Gansler, *Democracy's Arsenal: Creating a Twenty-First-Century Defense Industry* (Cambridge, MA: The MIT Press, 2011), 39.

within the DIB. Therefore, after the series of congressionally mandated closures and consolidations the defense industrial base footprint was diminished and the "depth and breadth" (meaning the number of like or similar facilities providing depth, where the breadth refers to large numbers of facilities), of this strategic capability was reduced. At the end of this period of downsizing, an adversary emerged with the attacks of September, 2001.

Post 9-11 Era (2001-Present)

Just a few years after the attacks of 9-11, the BRAC of 2005 closed additional DIB facilities.[39] These facilities consisted of two government-owned small-caliber production plants, leaving only one open, one government-owned medium caliber production facility, and three chemical storage facilities. With these closures the current day defense industrial base took shape. Now, in 2018, there are only six GOCO production facilities and thirteen GOGO storage and maintenance depots in the government-owned sector of the DIB.[40] This is a 92% percent drop in the number of manufacturing, storage, and maintenance facilities and bases compared to the DIB's size in 1945. In direct correlation with this consolidation and reduction in footprint on the government-side, the commercial defense sector continued the trend started in the 1990s of corporate mergers. In 1980, there were thirty large defense equipment production firms in the United States. Now there are only six large competitive defense corporations in the industry.[41]

The US infrastructure and manufacturing capability dedicated to supporting the military with key weapon systems, ammunition, repair parts, and storage facilities is as old as the nation itself. But, as discussed in the previous pages, after reaching its height of capability and size in the 1940s, the DIB has been down-sizing, placing the military's sustained readiness at risk. One

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[39] Ibid., 40.

[40] Ibid., 41-42.

[41] Jacques S. Gansler, *Democracy's Arsenal: Creating a Twenty-First-Century Defense Industry* (Cambridge, MA: The MIT Press, 2011), 46.

of the risks that has emerged as a result of the five separate rounds of BRAC in the 1990s and 2000s, is sole source production of, or a very limited number of sources of, specific weapon systems, repair parts, ammunition items, and explosive chemical mix components. [42]

Sole-Source Risk

As China and Russia improve their military capabilities there is a new era of great power competition on the global stage. Having vulnerabilities in the DIB like single sources of critical items and components is a strategic risk to military readiness and could impede mission accomplishment when faced with defeating a peer enemy on the twenty-first century battlefield. Military risk is most often manifested in the potential for a loss of capability to meet a mission or satisfy a given demand at a determined time and place of US choice, or the ability to force US will on the enemy while maintaining competitive advantage. Risk is calculated by assessing the severity, probability, or impact of losing a given capability, physical item, or control over intellectual property. As discussed in earlier pages, the steady downsizing of the DIB since the early 1950s has created a situation where the remaining manufacturing facilities, arsenals, and depots have become sole sources for some key items. This creates greater vulnerabilities and risk, if use of one of these sole sources is denied or even destroyed by an adversary.[43]

A key vulnerability or risk with a reduced DIB is sole sourcing, having only one manufacturing source for a critical item, or even having limited sources for key raw materials that are used in the DIB's production mission.[44] Having an extremely limited number of sources for critical items in the DIB undermines the ability of the DIB to sustain the US military's ability to project power globally and maintain high levels of sustained readiness. It significantly degrades

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[42] Brandon L. Grubbs, "Does the Defense Industrial Base Environment Create Strategic Risk?" (monograph, US Army War College, 2013), 9, accessed October 23, 2017, http://www.dtic.mil/docs/citations/ADA589330.

[43] Ibid., 7-8.

[44] Ibid., 10.

the ability of the DIB to sustain large-scale, high-intensity combat operations against a peer adversary that is capable of causing large scale losses of equipment and supplies, or more broadly, simply denying access to these critical items when they are required by US forces.

The phrase "don't place all your eggs in one basket" is commonly used as a teaching point in leadership and business schools to illustrate the risk of not having alternate means to obtain something critical to an organization in the event that the source of these items is either damaged, destroyed, lost, or simply not available for an extended period of time. Another lesson from this scenario is to mitigate risk of a total loss by having an alternate source for those required items, coordinating for storage, or saving up some of the critical items that can be used in the event that a production source is lost.

Radford Army Ammunition Plant Nitrocellulose Production

An example of a key component sole source risk is the DOD ammunition industry's reliance on nitrocellulose to produce military-grade propellants and explosive mixtures.[45] Effectively, all military munitions have some form of nitrocellulose compounds in them since they are essential to stabilizing explosives while in storage and in transport. Historically, from 1939-1990 this essential component was made by three separate GOCO plants located in three different states.[46] But after the five rounds of BRAC in the 1990s and 2000s, this essential component is only made at Radford Army Ammunition Plant (RAAP) in Radford, Virginia. [47]

RAAP is now the only plant, government or commercial, in the United States that produces this compound, thus creating a potential single point of failure in the supply chain for explosive mixes used in aircraft bombs, missiles, rockets, artillery rounds, tank rounds, mortars,

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[45] Gustave F. Perna and Alan R. Buester, "Securing the Base," *Military Logistics Forum* 6, no. 1 (February 2012): 42.

[46] Ibid., 43.

[47] Ibid.

and medium and small caliber ammunition. Furthermore, because there are not many civilian applications or a demand for nitrocellulose, commercial chemical companies like DuPont, ExxonMobil, and British Petroleum have not invested capital in maintaining a production capability for nitrocellulose.[48] The risk is that an attack by an adversary could disrupt or halt production. This creates supply chain issues for the production of many key ammunition components.[49] If the United States enters into a high-intensity, long-term conflict with a peer adversary, having one source also inhibits a rapid surge in order to meet expanded demand and places military force projection and sustained readiness at greater risk.

Another effect of limited sources for the last twenty years is the slow but steady erosion of new research, limited rapid expansion capability, and Americans working in the defense equipment engineering and chemist workforces that produce military grade nitrocellulose.[50] There is a shrinking pool of knowledgeable and qualified experts on both the government and commercial sides of the defense industry to lead a production surge of nitrocellulose. Training a new generation of engineers, chemists, and chemical production specialists would take years, not weeks.

Any disruptions or stop in the production of nitrocellulose has many supply chain effects on the production of many different ammunition items. One of those is small-caliber ammunition production.[51] Nitrocellulose is the stabilizing compound for the primer mix used in small-caliber ammunition production. Any interruption in the supply chain of production materiel for small-

[48] Ibid., 43-44.

[49] Ibid.

[50] Ibid., 45.

[51] Brandon L. Grubbs, "Does the Defense Industrial Base Environment Create Strategic Risk?" (monograph, US Army War College, 2013), 8, accessed October 23, 2017, http://www.dtic.mil/docs/citations/ADA589330.

caliber ammunition could result in a shortage of ammunition for Soldiers fighting a long-term, high-intensity conflict with a peer enemy force.

Lake City Army Ammunition Plant Small Caliber Ammunition Production

Small-caliber ammunition is one example of an item that is used by every service member in the DOD. It is fired in high volumes in both training and combat environments making it essential to building readiness and surviving in combat. Having limited sources of these critical items creates a vulnerability in the DIB and puts the long-term surge capacity of this sector of production at risk. In the last seventy-five years the manufacturing capability for small-caliber ammunition that is owned by the DOD has decreased from twelve small-caliber production facilities to one, a 92% decrease in the production footprint.[52] Currently, Lake City Army Ammunition Plant (LCAAP) is the only DOD-owned, small-caliber ammunition manufacturer still in operation.[53] LCAAP is another example of the steady erosion of DIB capabilities, as it is now charged with providing over 90% of the small caliber ammunition to the entire DOD.[54]

One may question why the US commercial ammunition industry cannot meet any surge requirements. The answer is that the steady closing and consolidation of facilities for small-caliber ammunition on the government side was also mirrored in the commercial sector over the past seventy-five years. A recent manufacturing study done by the DOD office of Acquisition,

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[52] Mark W. Siekman, David A. Anderson, and Allan S. Boyce, "Small-Arms Ammunition Production and Acquisition: Too Many Eggs in One Basket," *Army Sustainment* 42, no. 5 (September 2010):21, accessed December 10, 2017, http://www.almc.army.mil/alog/issues/SepOct10/spectrum_smallarms_ammo.html.

[53] Ibid.

[54] Ibid.

Logistics, and Technology (AL&T), showed a decline in the number of companies that still operate small-caliber ammunition production facilities in the United States.[55]

Over the past few decades, the number of companies that are in the small-caliber ammunition production business has shrunk from over twenty companies to five. Many of the companies were forced to merge with larger defense contractors or even large industrial operations firms in order to stay competitive in the recent years of smaller DOD budgets and as a result of the Budget Control Act of 2012 (sequestration) which limited DOD spending.[56] Additionally, some of the commercial small-caliber companies who were operating contractors for the GOCO ammunition plants were forced to downsize when the GOCO plants closed. Once these plants started closing in earnest during the BRACs in the 1990s and 2005, these companies had to either generate new business opportunities, were forced to merge, or went out of business completely.

Given the parallel downsizing of the government and civilian small-caliber ammunition production plants, the DIB is at risk due to limited sourcing of this critical item. If an adversary attacked LCAAP or disrupted the plant's operations for an extended period of time while the US military was fighting a high-intensity conflict against a near peer threat, supply flow would be interrupted and US forces could not sustain offensive operations. Furthermore, if LCAAP is not able to produce, there is only limited capability in the commercial sector so the back-up surge capacity no longer exists.[57] Over the course of the entire war, from 1939-1945, GOCO small-

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[55] John Dowdy, and Elizabeth Oakes, *Defense Outlook 2017: A Global A Survey of Defense Industry Executives* (Washington, DC: McKinsey & Company Report October 2016), 21, accessed 14 November, 2017, https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/defense-outlook-2017-a-global-survey-of-defense-industry-executives.

[56] Jacques S. Gansler, *Democracy's Arsenal: Creating a Twenty-First-Century Defense Industry* (Cambridge, MA: The MIT Press, 2011), 37-38.

[57] Mark W. Siekman, David A. Anderson, and Allan S. Boyce, "Small-Arms Ammunition Production and Acquisition: Too Many Eggs in One Basket," *Army Sustainment* 42, no. 5 (September 2010):21, accessed December 10, 2017, http://www.almc.army.mil/alog/issues/SepOct10/spectrum_smallarms_ammo.html

caliber ammunition plants produced over 136 billion rounds. LCAAP's maximum production capability, even after a modernization of the plant in the mid-2000s, is around 2.1-2.5 billion rounds per year. Therefore, if the DOD were required to fight another high-intensity, large-scale conflict with a peer adversary, it would take almost thirty-five years to surge to the output levels required in our last large-scale, high-intensity conflict. Some will counter this point by saying that stockpiles of ammunition did not exist in 1939 and therefore the huge numbers were required. But this only strengthens the sole-source risk argument because to fight a high-intensity conflict like WWII it still took billions of rounds for training, mobilization, and combat operations. If US forces had to do that today, even with a "healthy" stockpile that is based on fighting the current small wars in Iraq and Afghanistan, the United States would fail.

These two examples are similar in that nitrocellulose and small-caliber ammunition and are used in a vast array of DOD weapon systems.[58] In addition, downsizing causes an erosion in the skilled labor force, and in the size of the trained engineering professional workforce with the knowledge of how to produce military specification small-caliber ammunition. This is similar to the loss of intellectual knowledge mentioned previously with regards to the precise chemistry used in nitrocellulose production. Also, as discussed previously, the recovery of this knowledge base once lost takes years, not weeks.

M1 Abrams Tank Production Plant (Lima, Ohio)

The previous examples of sole-sources have focused on ammunition and components of ammunition production but another sole-source risk exists in a different production sector of the DIB. The capability to produce superior weapons rapidly has been a strategic advantage of the United States ever since WWII, but the erosion of the DIB manufacturing footprint exposes yet

[58] Brandon L. Grubbs, "Does the Defense Industrial Base Environment Create Strategic Risk?" (monograph, US Army War College, 2013), 11, accessed October 23, 2017, http://www.dtic.mil/docs/citations/ADA589330.

another example of the sole-source risk. This risk is associated with having only one factory that makes the United States Army's main battle tank, the M1 Abrams.[59]

Over the last forty years, the M1 Abrams tank has been the strength of the US Army's and US Marine Corps' land-based combat power. However, since the end of the Cold War, production of tanks has decreased and the number of commercial and government suppliers has been reduced to one plant that makes the M1 Abrams tank. Additionally, as new tank production capability shrank, the DOD also reduced the number of locations available for tank repair and reset.[60]

A deeper examination of this problem begins with the number of tanks available compared to the DIB's ability to resupply new or refurbished tanks to the force in a long-term, high-intensity combat scenario. Currently, the US Army has fifteen armored brigade combat teams in the regular active force and reserve component, with a total of 1350 tanks (90 per brigade).[61] There are about an additional 1000 tanks in reset and storage facilities across the DOD. In a high-intensity fight against a peer adversary, weapons and munitions are expended at much higher rates than our current eroded and fragile DIB can repair or replace. In a 2017 article entitled, "Long Wars and Industrial Mobilization: It Won't Be WWII Again," retired COL Mark Cancian examined the historical damaged or destroyed tank numbers of a high-intensity tank land battle against a peer adversary. "Forecasting attrition in peer conflicts is hard because such conflicts are fortunately rare," said retired COL Cancian. Cancian used two primary historical

[59] Ibid., 9.

[60] Ibid., 13.

[61] John Chipman, *The Military Balance 2017, The Annual Assessment* (London, England: International Institute of Strategic Studies, 2015), 4-5, accessed March 22, 2018, https://www.iiss.org/en/publications/military%20balance/issues/the-military-balance-2017-b47b.

examples: the Yom Kippur war between Israel and Egypt in the 1970s and one of the great tank battle of WWII at Kursk in 1943.[62]

For example, in 1973, the Israeli Army lost 400 of their 1700 tanks, a rate of about one percent per day over the twenty days of increasingly lopsided combat. Of note, the Egyptian Army lost far more. Furthermore, the great tank battle of Kursk in 1943 caused very high tank losses. The Germans lost an average of fourteen percent per day over two weeks of combat, a rate that would eliminate all of their initial force. However, this was a relatively short engagement of unusual intensity.[63] It is therefore reasonable to assume that an intense peer conflict would destroy about one percent of the tank force every day.[64] That includes losses from all sources: combat, abandonment during retreat, sunk enroute to theater, and accidents.[65]

Given this attrition model, Colonel Cancian presented the following example:

> With all current fifteen armored brigades engaged, the armored force would lose thirteen tanks per day and on average 390 per month. By pulling in replacements from the tanks in maintenance and located in the training base, the armored brigade combat teams could stay at full strength for about two months. After that, the force would decline steadily: to seventy-four percent in month four (960 tanks), fifty-five percent in month five (715 tanks), forty-one percent in month six (533 tanks), and so on. By month nine, the force would be down to 158 tanks, equivalent to just two armored brigades. DOD estimates that the Lima Ohio tank plant could produce twenty-eight tanks per month.[66]

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[62] Abraham Rabinovich, *The Yom Kippur War: The Epic Encounter That Transformed the Middle East* (New York, NY: Schoken Books 2004), 67.

[63] John A. Dinges, "Exploring the Validation of Lanchester Equations for the Battle of Kursk." (thesis, Naval Postgraduate School, 2013), 13, accessed November, 19, 2017, http://www.dtic.mil/dtic/tr/fulltext/u2/a391617.pdf.

[64] Ibid., 127.

[65] Ibid., 146.

[66] Mark Cancian, "Long Wars and Industrial Mobilization: It Won't Be World War II Again," *War on the Rocks*, August 8, 2017, accessed 13 December, 2017, https://warontherocks.com/2017/08/long-wars-and-industrial-mobilization-it-wont-be-world-war-ii-again/.

The numbers used by Cancian are estimates and may not be exact attrition values. Furthermore, this production output given the above scenario will not sustain the long-term offensive capability of US armored brigade combat teams.

Having only one manufacturing plant to replace these damaged or destroyed key weapons risks the United States' ability to sustain power projection and long-term offensive operations. With the increasing number of high-tech components on the current version of the M1 Abrams, having limited manufactures for parts makes it harder to maintain the required levels of equipment readiness that involves intensive training and deployment readiness exercises. These directly influence the readiness of the US military and its ability to project ready forces globally.

Some that oppose these notions of increased risk to readiness would state that there is no peer tank threat currently for the M1 Abrams. Without a peer on the battlefield, the loss of tanks would be much less than many models project, therefore justifying cutting the number of production facilities to one and reducing the number of parts suppliers. They argue that our current fleet of tanks is sufficient based on threats with which the United States is currently engaged. However, this logic seems to look at the present and does not account for the strategic shifts going on globally with respect to increased capabilities in both China's and Russia's militaries.[67]

Another vulnerability in the DIB is the reduced capacity to produce, store, and distribute the modern, high-tech parts and components that keep our military weapon systems, like the M1 Abrams tank, operational. By not adapting our maintenance and supply systems rapidly enough to enable service members to accurately reflect repair part and key component demands, a data

[67] The President of the United States, *National Security Strategy of the United States of America*, (Washington, DC: The White House, 2017), accessed 22 January, 2018, https://www.whitehouse.gov/articles/new-national-security-strategy-new-era/.

void now exists that creates a flawed demand signal for these key items.[68] This data void drove both DOD-owned and commercial defense suppliers to stop manufacturing parts and equipment. Because of the data void, it appeared that there was no demand for these parts. Some of these parts suppliers even went out of business, therefore further reducing the depth and breadth of the DIB's supply base. Due to this reduction M1 Abrams parts are not stocked. This increases the length of time to get a new part because a new contract needs to be awarded so new items can be produced. This affects the sustained readiness of key combat platforms and creates greater risk to force readiness.

Without proper demand tracking and forecasting, the immediate here and now overshadowed planning and preparations for what could potentially be needed in future wars. Furthermore, US forces have been in a state of prolonged conflict in both Iraq and Afghanistan for over sixteen years and in both those conflicts many of the critical weapon systems that US forces rely on to fight a high-intensity conflict with a peer adversary, like the Abrams tank, have not been utilized. If they have been used, it has not been to a great enough degree to create a steady and stable demand signal for parts and key replacement components. Thus, the reduced demand signal resulted in the DIB's supply base shrinking and required parts are no longer being produced.[69]

Furthermore, government funding for certain items like Abrams upgrades and even additional armor brigade combat teams was cut because other weapons or munitions were being used to fight the wars in Iraq and Afghanistan. To some, this is just a case of temporary near-sightedness that can be quickly and easily corrected given new or emerging global threats like a more powerful China, a re-emergent Russia, or a nuclear-capable North Korea or Iran. However,

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[68] Brandon L. Grubbs, "Does the Defense Industrial Base Environment Create Strategic Risk?" (monograph, US Army War College, 2013), 13, accessed October 23, 2017, http://www.dtic.mil/docs/citations/ADA589330.

[69] Ibid., 14.

the industrial base cannot quickly adapt and change course and the commercial capacity no longer exists.

There are still productive manufacturing sectors in the United States, but these sectors would not adapt well in response to the need to produce more tanks, fuel trucks, helicopters, fighter jets etc. during a surge. During the industrial surge in WWII, the DOD was able to produce billions of rounds of ammunition, thousands of airplanes and hundreds of ships in a two to three-year period.[70] Today, even with modernized manufacturing, the sole-sourcing environment makes this surge no longer possible and the risk is amplified by years of decreasing funding to maintain capacity, modernize equipment and facilities, and employ the skilled workforce in the remaining DIB.[71]

Foreign Sources of Key Components (Gum Arabic)

When specific chemicals used to produce some of the key ammunition and military specific items are only available from foreign countries, this is another vulnerability in the DIB. Not having a US-based source presents risk given the possible scenario of a maritime blockade or supply chain interruptions during a large-scale conflict. Specific key chemical compounds that are essential to manufacturing small-caliber ammunition and, in many cases, other ammunition items are only available in foreign countries. Some raw key chemical compounds are either no longer found in the United States or, in some cases, were only ever found in foreign countries.[72] An example of a compound that fits into this category is gum arabic, which is used to bind the

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[70] Daniel H. Else, *The Arsenal Act: Context and Legislative History* (Washington, DC: Congressional Research Service, 2011),16, accessed November 11, 2017, https://digital.library.unt.edu/ark:/67531/metadc83994.

[71] Brandon L. Grubbs, "Does the Defense Industrial Base Environment Create Strategic Risk?" (monograph, US Army War College, 2013), 15, accessed October 23, 2017, http://www.dtic.mil/docs/citations/ADA589330.

[72] Defense Logistics Agency, *FY 2011 Strategic and Critical Materials Operations Report to Congress* (Washington, DC, 2012), 57-58, accessed 15 December 2017, https://www.dnsc.dla.mil/Uploads/Materials/FY11%20Operations%20Report%20- %20Signed%2002-23-2012.

primer explosive mix used in small-caliber ammunition.[73] This compound is only found in the root of an Acacia Senegal tree that grows in regions of Kenya and the Sudan.[74]

The reliance on foreign sole sources of key chemicals poses risk in a couple of different ways. One of the risks deals with not following US law. Currently, the Arsenal Act of 1920 states that the DOD must "buy American" first.[75] In addition, it prohibits the use of foreign sources for DOD equipment or materiel unless that is the only means of obtaining the requirement, which creates another potential sole source risk situation. The second risk is the risk of an adversary denying a foreign source to our DIB in the time of war, or even if we are not at war, denial by emplacing a maritime blockade or imposing blocks in an economic trade disagreement.

Flawed Funding Strategies

Along with sole sources in the DIB there is another vulnerability that creates strategic risk to military readiness and the ability to project military power around the globe. The lack of a long-term, comprehensive funding strategy for the DIB's infrastructure and continuing modernization efforts, coupled with the negative effects of the Budget Control Act of 2011, also known as "sequestration" undermines the DIB's ability to provide sustained support given a high-intensity, long-term conflict with a peer adversary. If DIB production and storage facilities are not properly maintained, the potential for extended breaks in production, and failure to meet mission requirements increases.[76] The DIB consist of depots, plants, and arsenals that are now over seventy-five years old, but much of DIB's infrastructure was not built to last over fifty years

[73] Ibid.

[74] Ibid., 59-60.

[75] Daniel H. Else, *The Arsenal Act: Context and Legislative History* (Washington, DC: Congressional Research Service, 2011),14, accessed November 11, 2017, https://digital.library.unt.edu/ark:/67531/metadc83994.

[76] Ibid.

without either major renovations or replacement. Many of the government facilities were built during the large-scale build-up of the defense industrial base, from 1938-1942. The GOCO facilities that supported allied efforts in World War II are either completely gone or are over seventy-five years old and have not been adequately updated or modernized due to decreasing defense budgets.[77] Budgets for the DIB infrastructure have steadily decreased over the past 25 years, and, since 2011, have been further diminished under sequestration.[78] Along with inherent safety risks this aging infrastructure carries higher maintenance cost and, in many ways, inhibits reconfiguring manufacturing space in order to gain efficiency and increase production outputs.

During the DIB's growth in the 1930s and 1940s, high production output levels were achieved by capitalizing on rapid growth and expanded funding for both commercial and government facilities.[79] Also, by sharing the best industrial practices of the day, both government and industry were able to take advantage of the modern, large defense manufacturing capacity that existed at the time. Because the facilities were new and state of the art for that time period, the DOD and commercial sectors did not incur large operating and maintenance costs and thus were able to use funding for research, engineering improvements, and expanding manufacturing outputs.[80] In contrast, the current day DIB consists of a combination of seventy-five year old buildings, aging production machines, and degraded base support facilities that drive up maintenance and operating costs while the DOD budgets decrease.[81]

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[77] Ibid., 16.

[78] Jacques S. Gansler, *Democracy's Arsenal: Creating a Twenty-First-Century Defense Industry* (Cambridge, MA: The MIT Press, 2011), 37-38.

[79] Ibid., 39.

[80] Ibid, 42.

[81] Jacques S. Gansler, *Democracy's Arsenal: Creating a Twenty-First-Century Defense Industry* (Cambridge, MA: The MIT Press, 2011), 37.

Modern manufacturing equipment and automation do increase outputs and efficiency to a certain degree but are limited in the use of aging buildings and floor space then only so much additional output can be generated. Eventually, to continue growing and producing even greater outputs, it takes more machines and more floor space to be able to arrange processes in the most efficient manner. These improvements cost money and must be funded through a long-term DIB funding strategy.[82] In the older DIB facilities, many of these improvements are virtually impossible, and the risk to the ability to meet production requirements grows as the building continue to age and the cost to maintain them grows. It eventually becomes much less expensive to tear down a building and build a new facility rather than keep an old facility in use.

The decline of funding for DIB infrastructure modernization and upkeep started in earnest in the mid-1970s and continues up through the current day. There was a short period of increased modernization funding but it was focused on very specific portions of the DIB and not holistically. Then, in the late 2000s, the financial crisis of 2008 placed greater stress on both the federal government and many sectors of commercial industry. The organic DIB was in the middle of a period of financial uncertainty and facing a growing trend of reduced budgets, coinciding with a concerted push to "right size" in order to cut cost. In response to the financial crisis in 2008, Congress and President Obama moved to put the nation on the path to recovery and passed the Defense Act of 2011, which placed constraints on the defense budget.[83]

Sequestration places a financial limitation on all defense spending and thus creates a situation where funding for the modernization and updating of the DIB continually takes a back

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[82] John Dowdy, and Elizabeth Oakes, *Defense Outlook 2017: A Global A Survey of Defense Industry Executives* (Washington, DC: McKinsey & Company, 2016), 21, accessed 14 November, 2017, https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/defense-outlook-2017-a-global-survey-of-defense-industry-executives.

[83] Todd Harrison, *What Has the Budget Control Act of 2011 Meant for Defense* (Washington, DC: Center for Strategic and International Studies, 2015), 9, accessed March 22, 2018, https://www.csis.org/analysis/what-has-budget-control-act-2011-meant-defense.

seat to current mission requirements, such as those raised by emergent threats like Syria, North Korea, and the continued spread of violent extremist organizations.[84] However, being a lower priority should not result in the DIB being so underfunded and, in some cases, neglected. A little-known factor and budget policy decision concerning how defense industrial base installations are managed and funded contributes to the degradation in some ways. Most Army installations are managed and funded through a US Army three-star command called "Installation Management Command" (IMCOM). Because a vast majority of the infrastructure budget is given to IMCOM to assist with modernization and upkeep of Army installations, IMCOM is staffed with infrastructure and civil works experts that know the systems and processes much better that the mangers of DIB installations.[85] The defense industrial base sites are not managed by IMCOM and therefore the project monies for modernization and new buildings pass through completely different channels.[86] This is the classic example of an organization getting separated from standard procedures. The net result is less focus is paid to the "outlier." Without experts at the DIB installations, these plants, arsenals and depots do not have as strong of a "voice" when competing for funding against traditional IMCOM installations.

Additionally, the current strategy for DIB funding is based on historical and projected demand analysis and trends[87]. This model works for a commercial entity that is focused on

[84] The President of the United States, *National Security Strategy of the United States of America*, (Washington, DC: The White House, 2017), accessed 22 January, 2018, https://www.whitehouse.gov/articles/new-national-security-strategy-new-era/.

[85] Todd Harrison, *What Has the Budget Control Act of 2011 Meant for Defense* (Washington, DC: Center for Strategic and International Studies, 2015), 12, accessed March 22, 2018, https://www.csis.org/analysis/what-has-budget-control-act-2011-meant-defense.

[86] US Department of the Army, Army Regulation (AR) 700-90, Army Industrial Base Process (Washington, DC: Government Printing Office, 2014), 5-6.

[87] Ibid., para 6-2.

maximizing profits. However, the primary objective of the DOD is to build and maintain readiness not make a profit.

Conclusion

> The ability of the military to surge in response to an emergency depends on our Nation's ability to produce needed parts and systems, healthy and secure supply chains, and a skilled US workforce. The erosion of American manufacturing over the last two decades, however has had a negative impact on these capabilities and threatens to undermine the ability of US manufacturers to meet national security requirements.
>
> —2017 *US National Security Strategy*

The defense industrial base has undergone some dynamic changes over the past seventy-five years starting with the reduction in the number of DOD-owned facilities in concert with changing demands over time that forced many civilian defense companies to either merge with other competitors or go out of business.[88] A legacy of World War II, the DIB once included over seventy manufacturing plants and over 100 storage depots and maintenance arsenals. The overall number of these industrial facilities has declined by over ninety percent over the last seventy-five years, beginning with the end of World War II, through the Korean and Vietnam wars, and plateauing with the completion of base closures driven by the last official BRAC Act in 2005.[89]

With the slow erosion of DIB, vulnerabilities have increased as capabilities decreased. These vulnerabilities, coupled with current security threats and potential future conflicts with a large, peer adversary, should cause concern, even if only to better inform national leaders of potential problems that need to be addressed with the strategic defense industrial infrastructure. The consequences of not looking into ways to mitigate these vulnerabilities will be negative for the military and more importantly US national security.

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[88] Jacques S. Gansler, *Democracy's Arsenal: Creating a Twenty-First-Century Defense Industry* (Cambridge, MA: The MIT Press, 2011), 39.

[89] Daniel H. Else, *The Arsenal Act: Context and Legislative History* (Washington, DC: Congressional Research Service, 2011),16, accessed November 11, 2017, https://digital.library.unt.edu/ark:/67531/metadc83994.

Mitigating Key Vulnerabilities

Government senior leaders and commercial business leaders must look for the ways and means to limit or mitigate risks to the DIB. There will be competing interests at times between government and commercial entities but in the case of the DIB, risk mitigation will come from business solutions and contractual models that are mutually beneficial to both sides.

A common way individuals and organizations mitigate risk is to avoid what are referred to as single points of failure. This problem arises when there are only single sources of key required items, or in the case of intellectual capital or property, very few people with knowledge of how to accomplish a task to produce or build these key weapons and military munitions. In many facets the defense industrial base is a type of national readiness insurance policy.[90] In order for this insurance policy to work there cannot be single points of failure in the defense industrial base.

The government must partner with civilian industry to work to eliminate sole sourcing of military items. Many of the items that are used in producing military-grade equipment and arms are produced using very specific specifications and quality checks not used in the civilian sector of these manufacturing processes. This divide must be closed and these government specification processes must become more transparent. The government could provide financial incentives as a catalyst for increasing government and commercial partnerships. Another approach to reducing the sole-sourcing problem is to develop weapons and systems on platforms and with materials that are more widely used commercially. By doing so, more commercial entities will see a business opportunity, resulting in a broader, more capable, and more adaptable defense industrial base capability.

[90] Dennis L. Via, "AUSA 2011 Address" (speech, AUSA Conference, Washington, DC, October 2011), accessed October, 20, 2017, https://www.army.mil/article/172911/meet_your_army_gen_dennis_l_via_army_materiel_command.

In order to mitigate or even eliminate a majority of the current risk to the DIB a national strategy must be developed for the industrial base that supports the National Security Strategy and the National Defense Strategy to ensure that critical materiel and equipment readiness criteria are clearly defined. Once these criteria are defined, the strategy must be resourced to ensure that there is depth and breadth in the defense industrial base in both the organic and commercial sectors. Also, funding must be resourced to update aging infrastructure and modernize to ensure the surge capacity and responsiveness of the DIB. The depth of capabilities could also be obtained by stimulating businesses to develop these capabilities along with GOGO facilities, effectively eliminating the sole-source scenario.

Additional Risk to Explore Further

After examining the three key vulnerabilities discussed in previous sections, some other potential vulnerabilities or additional contributing factors have emerged. To continue working toward improving the DIB these issues need to be examined further. Four of these additional issues are: 1) the effects of a changed manufacturing and industrial environment in the United States, comparing the World War II era with the 21st century; 2) the effects of economic powers emerging like China that may start to challenge the advantage the United States has in term of "outspending our adversaries"; 3) changes in the American workforce in the past seventy-five years from an industrial and engineering focus to service industries; 4) the trend of outsourcing industrial work and moving manufacturing facilities overseas, which has reduced the industrial footprint and, in many ways, created limited source situations for key capabilities.[91]

The high levels of government investment in the 1940s provided flexibility to make items like military jeeps one month and make tanks the next month. Additionally, the industrial production boom was happening in the United States and the combined capacities of the

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[91] Jacques S. Gansler, *Democracy's Arsenal: Creating a Twenty-First-Century Defense Industry* (Cambridge, MA: The MIT Press, 2011), 37.

government and commercial sectors were expanding.[92] However, in the 21st century, the landscape has changed. Smaller production facilities exist in the commercial sector that produce small consumer goods and in many cases only assemble goods after components have been received from foreign sources like China. There are no longer large numbers of factories that can produce cars and airplanes and with only some minor modifications can shift to making tanks and warplanes.[93] In the 21st century the US auto industry has downsized and moved factories out of the United States, reducing industrial production capacity.

Additionally, in the 21st century the emerging markets for business growth are now in sectors such as elderly healthcare, high-tech computing devices, artificial intelligence, and world-wide-web commerce and retail sales not industrial production. America and a better part of the western world have evolved since the 1940s from making material and "hard" goods to providing services and improving capabilities to process, interpret, and store vast amounts of information needed to link a global, economic landscape in 2018. This shift in the landscape of western industrial capability creates a potential vulnerability in terms of being able to surge government and commercial defense industrial capability to meet a large-scale wartime demand.[94]

Another emergent environmental factor that creates risk to readiness and power projection is the shift in the global financial power balance since 1940. During the massive industrial surge in support of World War II the US economy had become the largest in the world and was three to five times larger than the economies of the adversaries it faced in Germany and

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[92] Daniel H. Else, *The Arsenal Act: Context and Legislative History* (Washington, DC: Congressional Research Service, 2011),6-9, accessed November 11, 2017, https://digital.library.unt.edu/ark:/67531/metadc83994.

[93] Jacques S. Gansler, *Democracy's Arsenal: Creating a Twenty-First-Century Defense Industry* (Cambridge, MA: The MIT Press, 2011), 45.

[94] Barry D. Watts, *The US Defense Industrial Base: Past, Present, Future* (Washington, DC: Center for Strategy and Budgetary Assessments, 2012), 18, accessed October 17, 2017, http://www.dtic.mil/docs/citations/ADA506796.

Japan.[95] Additionally, the United States invested almost forty percent of its entire economic capital in the war effort from 1941-1945.[96] To state it in simpler terms, the United States outspent its enemies because it could. Today, the United States views its largest potential adversaries as China, Russia, North Korea, Iran, and violent extremist groups. Even though the United States still has the largest economy in the world, it no longer holds the overwhelming advantage it did in the 1940s. China is quickly becoming a peer, economic competitor to the United States. Many economic projections place China as the world largest economy, based on gross domestic product, by the year 2030.[97] Thus, this peer economic rival creates a situation where the United States cannot simply outspend or outproduce its adversaries. Given the emergence of a peer economic power that has a rapidly growing industrial production capability, the United States is now forced to develop new cutting-edge technology and outthink its adversaries to maintain overmatch with its military weapons and ammunition.

A third economic environmental factor that has emerged is the shortage of industrial skilled workers in America. By current American Department of Labor numbers, in 2017 the United States is short almost 12,000 industrial engineers and almost 3.2 million skilled laborers.[98] As discussed earlier in this monograph, an example of where both the engineering shortage and the skilled labor scenario collide is in the small-arms ammunition production sector.[99]

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[95] Alan L. Gropman, *Mobilizing US Industry in World War II* (Washington, DC: Institute for Strategic Studies, National Defense University, 1996), 102.

[96] Ibid.

[97] Geoff Colvin, "Study: China Will Overtake the U.S. as World's Largest Economy Before 2030," *Fortune*, February, 9 2017, accessed March 22, 2018, http://fortune.com/2017/02/09/study-china-will-overtake-the-u-s-as-worlds-largest-economy-before-2030/.

[98] Mitra Toossi, *Labor Force Projections to 2022: The Labor Force Participation Rate Continues to Fall: Monthly Labor Review* (Washington, DC: US Bureau of Labor Statistics, 2013), 5, accessed March 22, 2018, https://www.bls.gov/opub/mlr/2013/article/labor-force-projections-to-2022-the-labor-force-participation-rate-continues-to-fall.htm.

[99] Ibid.

Finally, with the trend for outsourcing more low-tech, industrial manufacturing outside the United States, the United States is losing the foundation that is needed to execute a large surge in capacity and output. Commercial manufacturing plants in the United States no longer make cars, boats, and airplanes at the volumes or in the large number of facilities that once existed as recently as the mid 1970-1980s. These manufacturing plants have moved to other nations due to a myriad of factors. Some companies felt the need to move these plants out of the United States in order to remain competitive with foreign firms in a more global, economic environment. Higher corporate tax rates in the United States along with foreign nations providing larger financial incentives packages meant to lure American businesses to their countries also played a factor. Technology advancements, the enormous demand for small computing devices and smart-phones, the growing markets for home and office, and automation technology played a part in eroding the core industrial base capacity in the United States.

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