Mobilizing in the Twenty-First Century

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The U.S. approach to mobilization in the twenty-first century must leverage the critical factors that allowed the historic material output of the 1940s with the technological reality of future warfare against great-power competitors. While the United States has effectively demonstrated its surge capacity in recent years during operations in Afghanistan and Iraq, there are many significant challenges to mobilization

when facing a peer or near-peer competitor in large-scale combat operations. Ultimately, the United States only needs to mobilize better than its enemies.

Surge Capacity

> The joint publications do not define the term "surge." [However,] we can draw on historical examples in order to illustrate its meaning. The United States surged its military forces in 2007 for Operation Iraqi Freedom and 2009 for operations in Afghanistan. The face of these surges was the increase of American forces—i.e., personnel and their organic unit equipment. However, the unseen or forgotten piece of these surges was the necessity for sustainment resources provided by the industrial base. The primary provider of sustainment resources is the United States' organic industrial base composed of the services' depots and arsenals.[1]

In order to support the Iraq and Afghanistan surges, the depots and arsenals increased production and direct labor hours as much as three times more than their pre-2003 levels.[2] Depots and arsenals normally do not operate at maximum capacity in order to provide surge capabilities. As outlined in Department of Defense Publication 4151.18-H, *Depot Maintenance Capacity and Utilization Measurement Handbook*, reserve capacity "is retained to support the projected requirements of the Joint Chiefs of Staff contingency scenarios; but is not utilized under normal conditions."[3] While successful in sustaining the warfighters during overlapping surge operations in Iraq and Afghanistan, these operations significantly stressed the current U.S. industrial base capacity. Extending this concern further, the current industrial base is limited in its ability to support the surge of current U.S. forces. For example, Mark Cancian from the Center for Strategic and International Studies states that existing tank production facilities can only replace two days of battle losses per month.[4] Combining Iraq and Afghanistan operations and using them as a basis of comparison, the current U.S. industrial base appears capable of a limited-duration surge against a peer adversary. However, as Cancian's statement demonstrates, the United States is currently incapable of a prolonged conflict against a peer adversary. Therefore, a protracted conflict against a peer adversary would require the United States to mobilize in order to ensure victory.

U.S. Mobilization Capabilities

The United States maintains sufficient resources for a protracted surge against a regional adversary or a limited duration surge against a peer adversary, but it would have to mobilize for any conflict beyond these scenarios. Consequently, it is imperative to understand the United States' current mobilization capabilities. The previous Iraq and Afghanistan surges demonstrated the United States' limited surge capacity; therefore, a mobilization analysis must focus on capability rather than capacity. First, it is important to understand mobilization. Joint Publication 4-05, *Joint Mobilization Planning*, defines mobilization as "the process of assembling and organizing national resources to support national objectives in time of war or other emergencies."[5] World War II provides the best illustration of U.S. mobilization and the effort and resources necessary to accomplish mobilization. World War II teaches that the United States' prodigious level of mobilization depended on free enterprise. As Arthur Herman highlights numerous times in his book *Freedom's Forge*, mobilization must be decentralized so free enterprise can dominate.[6] Henry L. Stimson, the secretary of war during World War II, and Bill Knudsen, the architect for U.S. mobilization, held a similar belief. Herman encapsulates their belief when he writes, "The only way for America to prepare for war was through American private enterprise."[7] Private enterprise must lead mobilization and will depend on four critical factors: labor, material, manufacturing, and transportation. Labor—and more importantly, skilled labor—is critical in order to mobilize. According to U.S. Census Bureau data, the current population is nearly two and one-half times larger now than it was during World War II.[8] Additionally, during World War II, there was a significant use of labor that was

Previous page: Illustrative example of 3D printing being used in military operations at the point of need. (Illustration from *3D Opportunity in the Department of Defense: Additive Manufacturing Fires Up*, Deloitte University Press, 2014)

not initially skilled to accomplish the jobs that needed to be performed. Herman expertly documents that as early as 1941, women, who in most instances were not initially skilled in the areas they worked, were making significant contributions to the production of war items.[9] While a robust debate is possible, labor will not be examined herein as a critical constraint to U.S. mobilization. Rather, the focus will be on material, manufacturing, and transportation.

Material. Mobilizing requires belligerents to make items of war in large quantities in order to conduct war and replace those items as they are destroyed. These war items depend on materials. For example, materials of significant importance that serve as barriers to U.S. mobilization are aluminum, steel, and rare earth metals. These materials are ubiquitous across weapons systems. "Wrought aluminum plate, and specifically cold-rolled plate, is essential for armoring U.S. ground combat vehicles, constructing Navy ships, and building military aircraft."[10] Aluminum production in the United States has significantly decreased. The United States accounted for 16 percent of global aluminum in 1999 and only 4 percent in 2013.[11] During this same period, China's aluminum production increased from 11 percent to 47 percent.[12] Including the allies and partners of Canada, Western Europe, and Australia, aluminum production is still significantly less than China's aluminum production. In 2018, China produced an estimated 36,485 metric tons of aluminum compared to the 9,424 metric tons produced by the United States and its allies and partners.[13] This is a significant barrier to the United States' ability to mobilize.

Like aluminum, steel is also necessary for most weapon systems. U.S. production of steel has encountered a similar fate as aluminum. From 2010 to 2018, U.S. steel production decreased from 5.6 percent to 4.8 percent of the global total.[14] Similarly, if the European Union, North American, and Australian total steel production is combined, it only accounts for 16 percent of global production.[15] Conversely, China's production of global steel during this period increased from 44.5 percent to 51 percent.[16] While the United States' drop in steel production is not as drastic as aluminum, China's dominance in global steel production is comparable to its aluminum production supremacy. Equally concerning is the continued pressure China places on the global steel industry. China uses dumping, illegal export subsidies, and overproduction in order to decrease prices and drive competitors out of business.[17] As a result, steel production serves as a second major barrier to the United States' ability to mobilize.

Rare earth metals serve as a third barrier to the United States' ability to mobilize. "Rare earths are critical elements used across many of the major weapons systems the U.S. relies on for national security, including lasers, radar, sonar, night vision systems, missile guidance, jet engines, and even alloys for armored vehicles."[18] Rare earth metals are not required in large quantities, but their limited supply and difficulty to mine and process present a similar challenge as aluminum and steel for mobilization. In the same way China dominates the global aluminum and steel markets, it also dominates the global production of rare earth metals. The 2018 United States Geological Survey data show China's mines produced 120,000 metric tons, or 86 percent, of global rare earth metals, with Australia and the United States following with 20,000 and 15,000 metric tons, respectively.[19] Similar to aluminum and steel, China has used its dominance in rare earth metals to affect global markets. Moreover, it has used its rare earth metals dominance for reprisals. In 2010, China cut off rare earth metal supply to Japan over a territorial dispute.[20] Rare earth metals along with aluminum and steel are critical materials necessary for mobilization. However,

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Concept art showing a notional swarm of unmanned aerial vehicles. Using 3D printing technology, deadly swarms could be created quickly at significantly lower cost. (Illustration courtesy of the Air Force Research Laboratory)

like labor, materials are only inputs to the manufacturing processes required for United States' mobilization.

Manufacturing. Like material, manufacturing is critical to mobilization. If the United States dominated the global markets in aluminum, steel, and rare earth metals like China, but did not have the manufacturing capability necessary to process those materials into war items, it would still be unable to mobilize. In 2010, China surpassed the United States as the largest manufacturing country in the world.[21] There are a variety of causes for the U.S. decline as the world's leader in manufacturing. It is partly a natural byproduct of globalization but also the predatory practices of countries like China have proven damaging to U.S. manufacturing.[22] As a result, "some manufacturing capabilities can only be procured from foreign suppliers, many of which are not domiciled in allied and partner nations."[23] This decline in manufacturing is a major concern for strategic and military planners when they recall the prodigious manufacturing output of World War II. However, while it should be a matter of concern, it is often forgotten that the United States was completely ill prepared in 1939 to produce at the levels accomplished at the peak of production in 1944. Herman writes, "Everywhere Knudsen looked, he saw an American industrial base woefully unprepared for the scale of demand that would be placed on it."[24]

With this in mind, the United States is not in uncharted waters. Nevertheless, the manufacturing marvel of World War II required time. Time will not be a luxury available in major combat operations against a peer adversary where combat power is consumed at extraordinary rates.[25] "Conversely, the U.S. cannot afford to maintain a war-like footing in perpetuity."[26] Therefore, the United States will have to rely on innovation and what both Henry L. Stimson and Bill Knudsen understood: free enterprise.

Transportation. Materials and manufacturing serve as significant mobilization barriers for the United States, but equally constraining is transportation. Major combat operations requiring mobilization will require a herculean transportation effort. The 1991 Desert Storm buildup and sustainment is the most recent example the United States can draw from for massive transportation requirements. By the end of the war, the United States had moved 459 shiploads totaling 945,000 pieces of unit equipment along with 9.2 million tons of cargo to sustain the war effort.[27]

While these numbers seem significant, they are exponentially less than the numbers achieved mobilizing for World War II. Moreover, U.S. organic transportation assets were woefully unable to accomplish the tasks. Mobilization and sustainment depended on private and foreign shipping assets, along with significant foreign line-haul trucking and bus support in theater.[28]

adversary. Developing technologies can help reduce production times. These technologies cover a wide array of topics such as artificial intelligence, quantum computing, autonomous vehicles, advanced manufacturing, and others. The Nation must invest now in the technologies with the potential to diminish, if not solve the three critical barriers outlined above. Advanced

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Desert Storm was a war against a far inferior adversary where transportation assets operated in uncontested waters and land. Conversely, scenarios requiring the United States to mobilize will require drastically more transportation assets than those that were significantly strained during Desert Storm. Transportation, in addition to material and manufacturing, serves as a critical barrier preventing the United States from mobilizing, and like manufacturing, will require innovation and free enterprise to overcome.

Mitigation and Implications

The United States can surge against a non-peer adversary for a protracted duration but only for a limited duration against a peer competitor. Conversely, the United States is incapable of mobilizing, and it is focused on three major challenges currently preventing the Nation from successfully mobilizing. It does not produce sufficient war materials, specifically aluminum, steel, and rare earth metals. Also, it lacks the manufacturing necessary to turn materials into war items, and it depends on a peer competitor for its supply of rare earth metals. However, there are ways the United States can mitigate these barriers to mobilization.

As Stimson and Knudsen understood, the most important component that led to a successful mobilization during World War II was the Nation's free enterprise system. Assuming the Nation embraces this powerful lesson, free enterprise will prevail again. However, ramping up free enterprise for wartime production takes time, and as previously stated, time is not a luxury the United States may have against a peer

manufacturing, specifically additive manufacturing, commonly called 3D printing, has this potential. 3D printing acts like a home ink printer. Instead of a single layer of ink, it adds layer upon layer of a material to produce a three-dimensional item without requiring tools or molds.[29] Additive manufacturing technologies have widespread applications. "Some have gone so far as to suggest that their advent signals that we are on the cusp of the next industrial revolution, with technological, social, environmental, and economic implications stemming from these innovations."[30] Additive manufacturing has the potential to revolutionize combat sustainment by decreasing the strain on the industrial base during a surge and enabling weapon production during mobilization. Once combat operations begin, sustaining the force becomes critical and challenging. "Techniques like 3D printing could allow soldiers to replace parts for systems and equipment almost at the point of need."[31] As a result, it would significantly reduce supply and logistic chains, along with eliminating the need for large logistic bases to store and secure the parts.[32] Furthermore, "advanced manufacturing can also be used to address obsolete parts, hard-to-get parts, and diminishing sources of supply."[33] These are a few of the benefits advance manufacturing technologies like 3D printing can provide the Nation during a surge.

In the same way that it can transform how the Nation surges, advance manufacturing technologies can potentially solve many of the barriers to mobilization. As noted, availability of war materials like aluminum, steel, and rare earth metals is scarce. 3D printing can significantly mitigate the United States' inadequate

availability of these materials because "it is logically possible to restructure the manufacturing footprint into distributed 3D printing facilities that could feed off local materials."[34] Additionally, additive manufacturing (AM) offers overwhelming flexibility over traditional manufacturing (TM).

> Whereas TM often requires a high utilization rate for efficient production, AM can be easily shut down temporarily, or capacity can be redirected to the production of different types of goods. As a result, whereas traditional plants that produce for the mass market are much larger than those operating in the same industry producing customized products, AM plants can be very small without a loss of efficiency.[35]

The ability to transition from large, costly industrial facilities to small, decentralized operations without losing production capacity is the critical benefit 3D printing technologies provide. The reduction in facility costs and the flexibility to change product lines provides opportunity for a wider segment of the economy to enter the market.[36] Equally important is the ability for 3D printing to mass produce large items. Additionally, "AM technology is evolving rapidly and new materials and processes that expand the scope of what can be printed are revealed daily: large area printers that can print large products such as airplane wings and houses, printers that use multiple materials including conducting ones, rapid printing, and much more."[37] The production potential of additive manufacturing is nearly limitless, thereby offering the United States a path to overcoming its material and manufacturing constraints.

Additive manufacturing can also play a major role in mitigating transportation challenges during mobilization. During World War II, the United States produced nearly 52 million tons of merchant shipping in order to transport the prodigious manufactured war resources to the European and Pacific battlefields.[38] Because 3D printing allows production at the point of need, it can significantly reduce transportation requirements. This is critical to transportation requirements both in the manufacturing process and delivery to the end user. By employing it, "transportation by sea, land, and air will be drastically reduced."[39] While materials, manufacturing, and transportation are only three of many barriers to the Nation mobilizing, they are the critical drivers for success. Consequently, if the United States invests now and continues to innovate in these technologies, during a national emergency requiring mobilization, it is possible that the Nation's industry could more quickly convert to a wartime footing.

The implications of not investing in additive manufacturing are far-reaching. This technology will revolutionize both warfare and the global economy. It has the potential to reverse globalization and the effects it has on the Nation's manufacturing sector. Because it can "drastically simplify the supply chain" and reduce the need for unskilled labor, U.S. corporations will no longer need to manufacture offshore.[40] Also, since additive manufacturing reduces the barriers to entry, it will be more ubiquitous across both small and large businesses. The idea that markets will be more competitive because the economy of scale that large businesses enjoy no longer applies due to changeover costs and a greatly diminished price per unit.[41] However, it does not displace large companies because they can choose to remain global producers. For example, UPS "is in the process of

Above: The Shooting Star quadcopter drone designed for light shows by Intel. **Next page:** The Intel team produces a 1,200-drone light show featuring Intel Shooting Star drones 9 February 2018 for the PyeongChang 2018 Olympic Winter Games opening ceremony in Pyeongchang, South Korea. The drone show demonstrated the power of unmanned aerial systems working in a swarm. (Photos courtesy of Intel)

establishing 3D printing factories around the world that will produce just about anything for other companies."[42] These factors are critically important as they reduce the manufacturing shortfalls and production speed necessary to successfully mobilize against a peer adversary.

The defense sector is beginning to leverage this nascent technology and to better understand its potential to revolutionize warfare. The Army's Futures Command is starting to incorporate capability requirements predicated on advance manufacturing technology.[43] Additionally, the Army has fielded 3D printers in Afghanistan and Kuwait to support operations in those areas.[44] Similarly, "the Chief of Naval Operations' Rapid Innovation Cell has permanently installed one printer on the USS *Essex* and has plans to install 3D printers on two additional ships."[45] More importantly, additive manufacturing coupled with artificial intelligence has the potential to revolutionize how the United States prosecutes war. The military is experimenting with "rapidly producing customized drones 'outfitted for specialized missions.'"[46] Additive manufacturing easily allows the mass production of small, unmanned vehicles that use limited materials and resources. Augmenting it with artificial intelligence presents a potential revolution in military affairs. Swarms of unmanned drones can serve any number of battlefield functions. In so doing, because they are easy to produce, battlefield losses become significantly less of a concern to planners. Consequently, they can replace the extraordinarily expensive, highly technical, and time-intensive platforms that require significant material and manufacturing resources.

While the benefits of additive manufacturing coupled with artificial intelligence can change the way the United States wages war, they are also readily available to U.S. adversaries, both peer and non-peer. In 2015, students at the Naval Postgraduate School demonstrated the ability to control fifty unmanned systems with a single operator.[47] However, more recently, China set a record with over one thousand drones operating and interacting autonomously.[48] Thus, it is not irrational to postulate that the Nation and its peer adversaries could quickly find themselves in a Cold War-era military posture of mutually assured destruction, albeit a nonnuclear destruction. Similarly, this technology allows non-peer adversaries more military parity. Underdeveloped countries and terrorist

organizations can use additive manufacturing to leapfrog traditional, resource-intensive manufacturing processes.[49] These factors necessitate the United States' investment in additive manufacturing. The consequences of not investing will allow U.S. adversaries to gain a significant military advantage through technology overmatch that will put U.S. national security in jeopardy.

Conclusion

There is a difference between a surge and mobilization, and the United States faces barriers to successfully mobilize. While a surge places considerable strain on the Nation's military industrial base, the base currently maintains enough capacity to support a protracted surge against a non-peer competitor and a limited surge against a peer. Conversely, the United States is unprepared for the demands that mobilization would place on the country. It suffers from considerable shortfalls in the materials—specifically aluminum, steel, and rare earth metals—manufacturing, and transportation capabilities. Advanced manufacturing could be the keystone that bridges these gaps. As the United States learned during World War II, free enterprise is the bedrock on which mass mobilization is successful. Free enterprise will always support technologies that enhance the bottom line, but the United States must invigorate and invest in those technologies that have significant national security potential such as additive manufacturing. The Nation's adversaries are leveraging and will continue to leverage this technology to gain an asymmetric advantage; however, if the United States fails to lead in this technology, the country's peer competitors are more likely to achieve dominance. ■

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