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ARSENAL IN TRANSITION

LESSONS FROM WORLD WAR II INDUSTRIAL CONVERSION

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Executive Summary

Since the end of the Cold War, the United States has experienced a period of prolonged peace characterized by a distinct military advantage and a transition to counterinsurgency operations in the Middle East. The resurgence of great power competition has fundamentally shifted U.S. priorities toward preparing for large-scale conflict with a peer adversary, which would tax the U.S. industrial base more severely than any war in the last three decades. Such a conflict would demand an industrial mobilization strategy that aligns military requirements with current production capabilities in the defense industrial base (DIB); however, current capacity shortfalls could leave U.S. warfighters dangerously underresourced from the very outset of hostilities. The United States can address this challenge by exploring a wide range of industrial mobilization options that simultaneously increase peacetime capacity in the DIB and establish rapidly scalable production infrastructure.

This historical report examines the automobile industry's transition to wartime production at the onset of World War II and the factors that shaped American production capacity in the face of unprecedented demand. It then identifies historical lessons for modern mobilization planners and examines the feasibility of implementing industrial conversion practices to augment the modern DIB.

Chapters 2 and 3 outline the history of World War II industrial mobilization by the United States and the challenges of converting the automotive industry, which include conflicts between corporate financial interests and government authorities, a lack of prewar production infrastructure, and difficulties in mass-producing complex military equipment for the first time. These obstacles were largely addressed through enhanced government regulation governing commercial production and the use of raw materials, increased government investment in industrial capacity, and inherent adaptability in the automotive industry and the government's contracting processes. Chapter 4 uses tank manufacturing as a case study to examine how these factors affected the conversion process and production outputs.

Chapter 5 highlights the following historical lessons to guide modern mobilization planners:

1. **The United States must build defense production capacity during peacetime to prepare the DIB for increased wartime demand.** Defense readiness is not necessarily about producing weapons today; it is about positioning the DIB to scale rapidly for future conflict. Future mobilization plans must anticipate production surges across the full spectrum of conflict to manage strains on resources.

2. **Rapid advances in emerging capabilities can hinder production outputs. The DoD can mitigate these effects by improving adaptability in acquisition and production processes.** World War II defense production was marred by costly, time-consuming changes to equipment design. Future mobilization efforts will face similar challenges as battlefield lessons drive technological change. The DoD can minimize the impact of these challenges by increasing experimentation, improving equipment modularity policies, and providing clear requirements to defense contractors.

3. **The demands of large-scale war will require the U.S. military to weigh the value of high-end capabilities against the need for scalable mass production.** Producing simpler, more affordable weapon systems that prioritize scalability over capability in production would reduce the strains on the DIB. The U.S. military must identify a balanced mix of high- and low-end combat platforms to ensure it can sustain conflict while maintaining its technological advantages.

4. **Policymakers can address future resource shortfalls by expanding stockpiles of critical materials and investing in reshoring initiatives.** During World War II, raw material shortages consistently constrained production as demand surged. Such vulnerabilities could have even greater consequences today due to global supply chains and rising raw material consumption across the United States.

5. **Building production capacity for high-intensity conflict requires balancing government regulation with free enterprise during times of crisis.** Pre–World War II industrial mobilization was marked by a persistent struggle between regulatory control and private industry interests. Comparable tensions could arise if the United States faces a prolonged crisis with Russia or China that eventually escalates to war.

Chapter 6 assesses the viability of industrial conversion as a cost-effective way to surge production capacity, mitigate production disruptions, promote competition, accelerate innovation, and address workforce shortages in the DIB. The Civil Reserve Manufacturing Network recently proposed by the House Appropriations Committee provides a conversion model designed to integrate businesses into a ready reserve capable of quickly transitioning to defense production when called upon. The DoD can align military requirements with participants in the Civil Reserve Manufacturing Network through four distinct approaches:

1. **Mass production of simple systems:** Identify simple-to-produce yet high-demand military items for mass production by companies serving in prime contractor roles.

2. **Subcontracting for complex systems:** Use participating companies as subcontractors to fill production gaps for complex military equipment produced by major defense contractors.

3. **Partnering with innovators:** Collaborate with leading innovators in emerging commercial technologies to improve legacy equipment and develop new military capabilities based on feedback from the battlefield.

4. **Leveraging contract manufacturers:** Leverage the expertise of contract manufacturers and original design manufacturers (ODMs) to increase scalability in weapon designs and production processes.

In addition to aligning commercial capacity with military requirements, an effective manufacturing reserve program must integrate corporations into mobilization planning, establish certification and oversight mechanisms, capitalize on flexible acquisition processes, and offer enticing financial incentives to attract participants.

Chapter 7 provides recommendations to ensure the long-term viability and complete integration of an industrial conversion program in the DIB. Most importantly, a successful program would require a dedicated government agency with clear legal authority across the full spectrum of conflict. A prospective conversion program also would require clearly defined military requirements from the DoD and semiflexible weapons design standards to enable broad participation from private industry.

Finally, the $131 million price tag proposed for the Civil Reserve Manufacturing Network is insufficient to achieve a meaningful, long-term impact on production capacity. Should U.S. policymakers pursue industrial conversion as a mobilization option, they must recognize that these programs entail significant upfront costs. Such industrial conversion practices may prove more cost-effective than building production infrastructure from scratch. Additional research is needed to determine the scale of investment required for future success.

CHAPTER 1

Introduction

> We build things in America—that is why most of the world is looking toward us, hoping and praying that we will come through. When we think of our boys in the Arctic or in the jungle standing up to overwhelming odds; when we think of our allies, the British, the Russians, the Dutch, and the Chinese, bravely bearing the brunt of the totalitarians, then we know the tide will turn.... America is in production now.
>
> —William S. Knudsen, Office of Production Management, January 1942[1]

These words are from an undelivered speech by William S. Knudsen, a Danish-born automotive industrialist appointed to lead U.S. World War II production efforts as head of the Office of Production Management (OPM). The speech was intended for a CBS broadcast showcasing the accomplishments of OPM to the American public. Knudsen was relieved of his position, however, just before the scheduled delivery after President Franklin D. Roosevelt's announcement of a newly established production coordination agency, the War Production Board (WPB).[2] Knudsen's sudden removal came amid growing public criticism that "OPM had not amounted to much; that conversion was being accomplished haltingly; that programs were lagging; [and] that the organization was inadequate."[3]

These criticisms reveal only a small portion of the difficulties government officials faced while converting America's civilian industrial capacity to defense production during World War II. Nowhere were these challenges more apparent and pressing than in the automobile industry, which the United States greatly relied upon to produce its arsenal of democracy. Major obstacles to conversion included conflicts between corporate financial interests and government authorities, the absence of prewar production capacity, and frequent design

1 Arthur Herman, *Freedom's Forge: How American Business Produced Victory in World War II* (New York: Random House Trade Paperbacks, 2013), p. 167.

2 Ibid., p. 164.

3 Whittlesey House, *Knudsen, A Biography* (New York: McGraw-Hill Book Company, 1947), p. 340.

changes caused by unprecedented difficulties in the mass production of military equipment. These obstacles were largely addressed through enhanced government regulation governing commercial production and raw materials, increased public investment in industrial capacity, and adaptability in the automotive industry and the government's contracting processes. The industry's early failures and eventual successes in World War II offer lessons for future large-scale conversion efforts, examined here through the lens of specific production case studies.

Report Purpose

The modern security environment has rapidly transformed to emphasize great power competition with peer adversaries. This development requires the United States to refocus on preparing for large-scale conflicts, but sustaining such conflicts will likely exceed the current capacity of U.S. defense infrastructure. U.S. policymakers must explore the full range of industrial mobilization options to ensure future production demands are met on time and within budget.

Industrial conversion, or the process of repurposing civilian industrial capacity for military use, is a resource-efficient mobilization option that has not been widely considered in recent decades due to the growth of dedicated defense contractors and America's prolonged involvement in counterinsurgency operations. An efficient and modernized industrial conversion program could surge production capacity during wartime at a much lower cost than government-funded infrastructure development. The transformation of the automotive industry during World War II serves as an excellent case study for examining the challenges of and best practices in industrial conversion.

This report provides a historical account of U.S. mobilization efforts from the interwar period through the end of World War II. It then examines critical production challenges faced by the automotive industry and the solutions implemented to address them, using tank production as a case study. It concludes by identifying lessons from World War II mobilization and highlighting policy mechanisms required for implementing a modern industrial conversion program.

Case Study Approach

World War II industrial mobilization practices varied greatly depending on the type of military goods being produced and the existing capabilities of the U.S. manufacturing base. Some military equipment, such as munitions, required entirely new production infrastructure due to their specific military purposes and the limited number of commercial factories available for conversion.[4] Conversely, items such as military trucks, jeeps, and small miscellaneous

4 Tyler Hacker, *Arsenal of Democracy: Myth or Model? Lessons for 21st-Century Industrial Mobilization Planning* (Washington, DC: Center for Strategic and Budgetary Assessments, May 2025), pp. 24–26.

war goods were mostly produced in converted facilities. More complex military platforms, including aircraft, tanks, and warships, required a combination of government-funded infrastructure and existing civilian manufacturing capabilities to meet production demands.

This report used the last two conversion methods described above as screening criteria to select a specific industry for analysis as a case study. The report focuses on a single industrial sector to offer a more detailed examination of how particular companies, business leaders, and government officials created (or combatted) industrial conversion policies. The report also analyzes manufacturing trends for specific military equipment to highlight the impact of these policies on production outputs. A broad range of industrial sectors and military equipment were considered before the automotive industry and tank production were selected.

Why the Automotive Industry?

The U.S. mobilization strategy leveraged nearly every major industrial sector for wartime production, but three distinct characteristics of the automotive industry make it particularly well suited for a case study on industrial conversion practices.

1. Automakers had more robust and sophisticated mass production capabilities than other industries at the time. This trait permits a more nuanced analysis of conversion that extends beyond the mere presence of industrial capacity.

2. The automakers' close coordination with the federal government enables an in-depth examination of the public–private relationships that are essential for industrial conversion.

3. The industry transitioned from purely commercial production to total defense production. Before 1939, no automobile manufacturers were involved in the production of military equipment, which forced the industry to either convert its existing commercial industrial capacity or construct whole new facilities to begin defense work. The dilemmas and challenges of this transition offer more valuable insights than other industries, such as the shipbuilding sector, which manufactured military equipment in preexisting facilities designed for military needs.[5]

Why Tanks?

The automotive industry produced a wide variety of war materials, including tanks, trucks, airplane engines, propellers, guns, ammunition, and amphibious vehicles.[6] This report provides a detailed case study of tank manufacturing to enable a deeper analysis of industrial conversion practices and their effects on production outputs. Tanks were chosen over

5 Mark R. Wilson, *Destructive Creation: American Business and the Winning of World War II* (Philadelphia: University of Pennsylvania Press, 2016), pp. 50–62.

6 Charles K. Hyde, *Arsenal of Democracy: The American Automobile Industry in World War II* (Detroit: Wayne State University Press, 2013), chaps. 3–7.

other military equipment because they were an emerging capability that was rapidly developed and produced at scale for the first time.[7] This case study is particularly relevant to the modern era, when emerging technologies like drones and hypersonic weapons could require accelerated production at scale in the event of armed conflict with a peer competitor.

Report Outline

Chapter 2 outlines the World War II industrial mobilization efforts of the United States through three time periods: interwar planning, the defense period, and the war period. It highlights significant production trends and the evolution of the government agencies responsible for mobilization.

Chapter 3 analyzes the U.S. government's efforts to convert the automotive industry from commercial production to defense production. It identifies three major challenges to this effort and the solutions implemented to overcome those challenges.

Chapter 4 includes a case study on tank production during World War II and links the challenges and solutions identified in Chapter 3 to tangible production outcomes.

Chapter 5 presents key lessons from World War II mobilization and the related tank case study to inform modern mobilization planning efforts.

Chapter 6 asserts that a modern industrial conversion program could effectively supplement the current defense industrial base (DIB) for future large-scale conflict. It introduces a recently considered conversion framework and examines key planning considerations for its implementation.

Chapter 7 summarizes the insights from previous chapters and highlights actions the U.S. government can immediately take to implement an effective industrial conversion program.

7 Kevin Thornton, *Tanks and Industry: The Detroit Arsenal* (Warren: History Office, U.S. Army Tank-Automotive and Armaments Command, 1995), p. 13; and Paul Sweeney, *Industrial Mobilization for War: History of the War Production Board and Predecessor Agencies 1940–1945,* vol. 2, *Materials and Products,* pt. 7, *Munitions of War* (Washington, DC: U.S. Civilian Production Administration, 1947), p. 227, World War II Administrative Histories (New Haven, CT: Research Publications, Inc.), microfilm, reel 391.

CHAPTER 2

From Prewar Planning to Full-Scale Production

World War II literature often partitions the U.S. mobilization effort into three distinct periods to describe how the nation created the arsenal of democracy: the interwar period, the defense period (also known as the rearmament period), and the war period. The interwar period provides insights into the decline of U.S. defense production capacity after World War I and the policies implemented in the 1920s and 1930s that impacted industrial conversion during the next great war. The defense period refers to the time during which escalation abroad prompted the United States to increase its military readiness, supply allies with military aid, and expand its domestic defense production capacity before entering the war. In this report, the defense period begins with Germany's invasion of Poland in 1939 and ends with Pearl Harbor. Finally, the war period denotes a time of all-out mobilization to support the country's direct involvement in the war, beginning with the U.S. declaration of war on December 8, 1941 and ending with victory over Japan (V-J Day).

The narrative of industrial conversion changes dramatically across these periods. The story begins with somewhat fragmented military planning efforts and limited cooperation by private industry during the interwar period. As tensions in Europe increased, the U.S. government gradually implemented measures during the defense period to incentivize and compel industry leaders to accept defense contracts. Finally, the war period is characterized by increased government authority and changing public sentiment, which create a rapid shift from government cooperation with industry to mandated policies that all but forced businesses to convert to defense production.

Interwar Period

U.S. defense production capacity decreased greatly after World War I, as many private businesses began converting back to commercial manufacturing and wartime government

controls were removed.[8] During this time, the War Department made concerted efforts to develop structured mobilization plans to avoid the inefficiencies that plagued the United States during World War I. The National Defense Act of 1920 authorized the War Department to develop industrial mobilization plans (IMPs), four of which were drafted between 1930 and 1939. The IMPs established a framework for increasing the end strength of the Army from 280,000 to 400,000 personnel within one month of a declared emergency, to one million within three months of a declaration of war, and to four million if the war continued for an extended period.[9] To equip such a force, the IMP also identified the need to mobilize the national economy by leveraging underutilized civilian capacity to manufacture 90 percent of munitions requirements.[10] The centerpiece of its recommendations was to establish a single, robust War Resources Administration responsible for coordinating the national economy, aggregating military requirements, and diverting resources from nonessential commercial production to support industrial conversion.

This plan had several flaws that persisted through its final version. First, it was developed primarily by military personnel with limited experience in industry.[11] This led to the false notion that existing civilian capacity could easily be adapted for military purposes. The plan also made no provisions for large-scale mobilization during peacetime, since it followed a timeline with a theoretical mobilization day that began with the declaration of war.[12] Military planners recognized this conceptual gap and sought to expand the plan's scope through legislation that would activate the IMP upon the declaration of a national emergency; however, the bill was never passed through Congress.[13]

This failure weakened the IMP's central proposal—to regulate industrial conversion through a centralized agency—because it did not account for the political resistance such an action would face in a prewar environment. The idea of such a powerful organization conflicted with the principles of the American economic system, and it thus encountered significant political opposition before the war. Roosevelt rejected the final version of the IMP in 1939 because he was unwilling to cede control of the American economy to such an agency or face

8 Wilson, *Destructive Creation,* pp. 21–39.

9 James Fesler et al., *Industrial Mobilization for War: History of the War Production Board and Predecessor Agencies 1940–1945*, vol. 1, *Programs and Administration* (Washington, D.C.: U.S. Civilian Production Administration, 1947), p. 3. The IMPs consisted of three separate but closely linked mobilization roadmaps: the Protective Mobilization Plan, the Procurement Plan, and the Industrial Mobilization Plan. The Protection Mobilization Plan was the initial military mobilization plan responsible for increasing the total force end strength when a crisis emerged. The Procurement Plan and the Industrial Mobilization Plan outlined procurement requirements and how the United States would mobilize the national economy to sustain the war effort. Together, these three separate plans are often referred to as the IMP.

10 Ibid., pp. 3–4; Wilson, *Destructive Creation,* p. 43.

11 Alan L. Gropman, *Mobilizing U.S. Industry in World War II: Myth and Reality* (Washington, DC: Institute for National Strategic Studies, National Defense University, 1996), p. 22.

12 Ibid., p. 19.

13 Fesler et al., *Industrial Mobilization for War*, p. 6; and MaryClaire McCauley, *Conversion of the Consumer Durable Goods Industry to War Production May 1940 to December 1944* (Washington, D.C.: WPB, 1947), p. 21, World War II Administrative Histories (New Haven, CT: Research Publications, Inc.), microfilm, reel 346.

the political repercussions of implementing extensive government controls in peacetime.[14] Despite this, Roosevelt later adopted many of the IMP's foundational principles into his own prewar mobilization strategy.

While the War Department was crafting its next mobilization plan, the rest of the nation maintained strong isolationist attitudes in the years leading up to World War II.[15] Congress passed two Neutrality Acts in 1935 and 1937 that prohibited arms sales to foreign nations involved in conflict. Appropriations for the War Department had already been drastically reduced to a new low of $243 million in 1934.[16] From 1931 to 1938, total annual military expenditures never exceeded $980 million—merely 1.0 to 1.5 percent of GDP.[17]

The United States did not take steps toward broader mobilization until 1938. In response to increased tensions in Europe, Roosevelt called upon Congress to increase defense spending to support numerous Army and Navy expansion programs.[18] Congress responded by passing several key pieces of legislation that laid the groundwork for future military growth, including the Fleet Expansion Act and the Educational Orders Act. The Fleet Expansion Act provided $1.1 billion to increase the size of the U.S. Navy by 20 percent and resulted in the construction of numerous aircraft carriers, battleships, cruisers, and destroyers.[19]

Most notably, the Educational Orders Act authorized the armed Services to provide no-bid contracts to familiarize manufacturers with the inner workings of defense production.[20] These contracts were mainly used for complex military items that required specialized expertise, machine tools, and other resources to produce at scale in wartime. Once a company received an educational order, it was required by contract to review the design of the item, recommend changes to the design to facilitate mass production, and obtain the necessary resources to validate its manufacturing methods.[21]

This act was the first major policy aimed at converting private industry to defense production, and it proved critical for preparing businesses for early defense contracts.[22] During this time, the War Department surveyed 25,000 private manufacturing plants to determine

14 Gropman, *Mobilizing U.S. Industry,* pp. 22–26.

15 Mark Cancian and Adam Saxton, *Industrial Mobilization: Assessing Surge Capabilities, Wartime Risk, and System Brittleness* (Washington, DC: Center for Strategic and International Studies, 2021), p. 9.

16 Ralph Smith, *The Army and Economic Mobilization* (Washington, DC: Office of the Chief of Military History, Department of the Army, 1959), pp. 123–125.

17 Cancian and Saxton, *Industrial Mobilization*, p. 10.

18 Franklin D. Roosevelt, "Message to Congress Recommending Increased Defense Appropriations" January 28, 1938, https://www.presidency.ucsb.edu/documents/message-congress-recommending-increased-defense-appropriations.

19 Cancian and Saxton, *Industrial Mobilization,* p. 11.

20 Hyde, *Arsenal of Democracy*, p. 5.

21 Smith, *The Army and Economic Mobilization*, p. 64.

22 McCauley, *Conversion of the Consumer Durable Goods Industry*, p. 58.

their suitability for defense work, and approximately 10,000 were identified for war production.[23] Many of these companies received educational orders in peacetime that enabled them to quickly transition to defense contracts in wartime. For example, Winchester estimated it could commence full-scale production of the M1 rifle a whole year earlier due to a previous educational order.[24] Additionally, the War Department considered educational orders essential for training its procurement officers to work with industry.[25]

Both the Fleet Expansion Act and Educational Orders Act were legislative efforts that signaled a shift from interwar mobilization planning to tangible defense preparedness. However, the combination of reduced military expenditure, adverse economic impacts of the Great Depression, and prevailing isolationist policies left U.S. military production infrastructure significantly underdeveloped. The War Department had only six munitions arsenals in operation during the interwar period; these could facilitate the production of just 10 percent of the war material needed for a force of one million men.[26] Although educational orders were effective for training industry and validating manufacturing processes, they were not designed to create capacity at the scale needed for World War II.

The Defense Period (September 1939–December 1941)

Germany's invasion of Poland in 1939 marked the beginning of the defense period, when U.S. mobilization efforts rapidly expanded year over year. In response to the invasion, Roosevelt proclaimed a limited national emergency on September 30 and initiated the Protective Mobilization Plan, which enabled the recruitment of a 400,000-man Army.[27] He also established the Office of Emergency Management (OEM) to oversee the growing network of defense support agencies.[28]

Congress took swift legislative action to support Roosevelt by appropriating an additional $32.5 million to the Educational Orders Act and passing the Air Corps Expansion Act, which authorized the production of 6,000 additional aircraft.[29] It also amended the Neutrality Act in November 1939 to allow direct arms sales to foreign countries on a "cash and carry"

23 Ibid., pp. 20–21.

24 Harry Thomson and Lida Mayo, *The Ordnance Department Procurement and Supply* (Washington, DC: Office of the Chief of Military History, Department of the Army, 1960), p. 20.

25 Smith, *The Army and Economic Mobilization*, p. 64.

26 Ibid., p. 498; and McCauley, *Conversion of the Consumer Durable Goods Industry*, p. 20.

27 Thomas Morgan, "The Industrial Mobilization of World War II: America Goes to War," *Army History*, no. 30, 1994, p. 31; and Fesler et al., *Industrial Mobilization for War*, p. 3.

28 Fesler et al., *Industrial Mobilization for War,* p. 18. OEM remained active throughout the war as the overarching agency coordinating efforts among various defense-related entities; however, it is often overshadowed in defense production literature due to its diminished role following the revival and expansion of the National Defense Advisory Commission and the establishment of the WPB.

29 Wilson, *Destructive Creation*, p. 58; and Hyde, *Arsenal of Democracy*, p. 5.

basis.[30] These efforts increased domestic military equipment requirements and foreign orders, but few private businesses substantially changed their industrial capacity to meet the growing needs.

The German invasion of the Netherlands, Belgium, Luxembourg, and France on May 10, 1940, accelerated the American transition toward peacetime mobilization. Less than a month later, Roosevelt reinstated the National Defense Advisory Commission (NDAC). This agency had been established during World War I to provide policy recommendations regarding mobilization, and its statute had never been rescinded by Congress. Roosevelt tasked NDAC with mustering the nation's industrial power to equip an Army of two million men, produce 1.5 million additional tons of Navy ships, and manufacture 25,000 aircraft.[31] NDAC consisted primarily of business executives and industrialists who left their private-sector roles to work for the U.S. government. They were popularly referred to as "dollar-a-year men" because they were paid a salary of one dollar to make their official service legal.

Dollar-a-year men like Knudsen were selected for their expertise in mass production and commitment to supporting the nation, but they did not have the authority to enforce actions on private industry or the armed Services. On paper, NDAC was granted substantial authority by Roosevelt to approve contracts, allocate funding for new facilities, and establish resourcing priorities.[32] In practice, however, the organization was consistently undermined by the military's control of the procurement process and the voluntary nature of private industrial conversion. NDAC also faced challenges in obtaining production requirements from each military Service and converting these requirements into raw material needs, which made it virtually impossible to coordinate resource prioritization at the national level.[33] Finally, NDAC suffered from a lack of central leadership, which caused duplicate efforts across its divisions and significant internal conflict.[34]

Despite these shortcomings, NDAC was crucial for implementing a $9 billion defense expansion program that included 531 separate manufacturers.[35] It initiated many industrial conversion programs, including facility expansion, priority allocation, and requirement forecasting, that proved critical to success during wartime production. However, NDAC's lack of legal peacetime authority rendered it incapable of meeting the expanding produc-

30 Robert Patterson, *Arming the Nation for War: Mobilization, Supply, and the American War Effort in World War II,* ed. Brian Waddell (Knoxville: The University of Tennessee Press, 2014), p. 37.

31 Paul A. C. Koistinen, *Arsenal of World War II: The Political Economy of American Warfare, 1940–1945* (Lawrence: University Press of Kansas, 2018), p. 47.

32 Koistinen, *Arsenal of World War II*, p. 48; and Fesler et al., *Industrial Mobilization for War*, pp. 22–28.

33 McCauley, *Conversion of the Consumer Durable Goods Industry*, p. 36.

34 Fesler et al., *Industrial Mobilization for War*, p. xv; and Hyde, *Arsenal of Democracy*, p. 17.

35 Morgan, "The Industrial Mobilization of World War II: America Goes to War"; and Hyde, *Arsenal of Democracy*, pp. 19, 42.

tion demands in 1941. U.S. defense spending increased from $3.6 billion to $17.8 billion from 1940 to 1941, which placed immense strain on domestic production capacity; this challenge was compounded by surging foreign orders, particularly from Britain, whose purchases totaled $2.7 billion by the end of 1940.[36] The spike in domestic and foreign demand led to shortages in facilities and essential raw materials across nearly all industries, which highlighted the need for a stronger and more centralized agency than NDAC. To address these challenges, Roosevelt replaced NDAC with OPM in January 1941.[37]

OPM was an improvement over its predecessor agency, but it was plagued by a similar lack of authority, disputes with rival agencies, and resistance from the armed Services.[38] Later sections of this paper will examine these challenges in more detail, but it is important to note that OPM implemented centralization mechanisms that were not fully accomplished under NDAC. By the end of 1941, the United States saw significant improvement in its defense production capacity due to this centralization, although the full industrial capability of the country was only realized after it entered the war.

The War Period (December 1941–August 1945)

The attack on Pearl Harbor fundamentally altered the U.S. mobilization effort. With America at war, many of the challenges that NDAC and OPM encountered during peacetime were addressed through increased government regulation and presidential wartime powers. In a message to Congress, Roosevelt called for a fourfold increase in military spending to produce 60,000 aircraft, 45,000 tanks, 20,000 anti-aircraft guns, 500,000 machine guns, and 8 million tons of merchant ships.[39] A government study conducted in late 1941 (see Figure 1) determined that the U.S. economy could realistically sustain up to $40–45 billion in combined defense expenditures; however, Roosevelt's new objectives were estimated to require an expenditure of $50–55 billion in 1942.[40]

36 Hyde, *Arsenal of Democracy*, p. 42; and Fesler et al., *Industrial Mobilization for War*, p. 51.

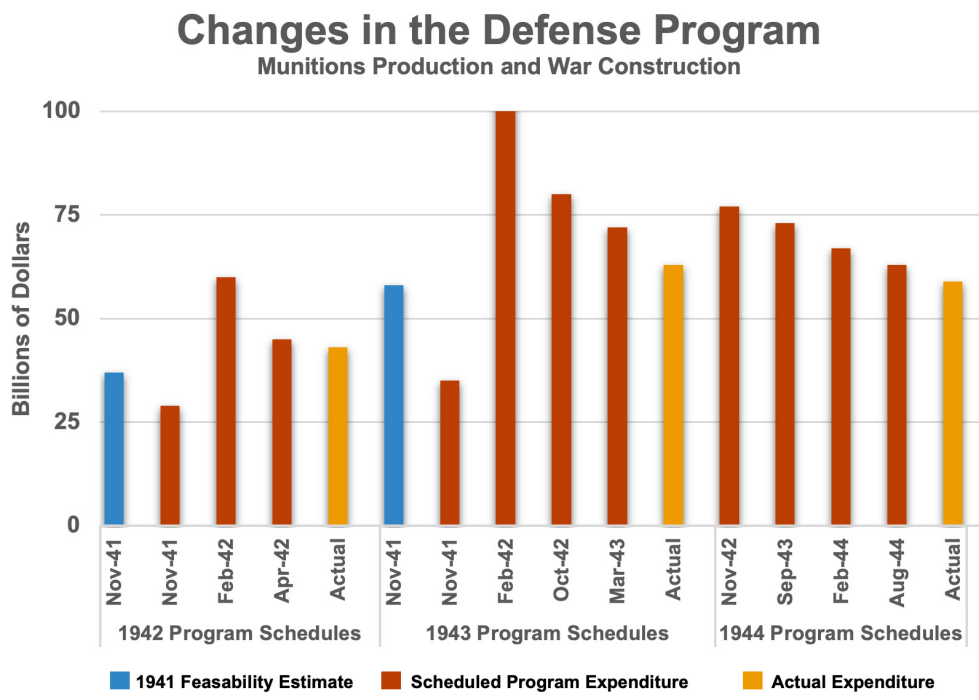
37 Patterson, *Arming the Nation*, p. 100; and Hyde, *Arsenal of Democracy*, p. xv.

38 Koistinen, *Arsenal of World War II*, p. 73.

39 Hyde, *Arsenal of Democracy*, p. 29.

40 Fesler et al., *Industrial Mobilization for War*, p. 273; and Hyde, *Arsenal of Democracy*, p. 29.

FIGURE 1: CHANGES IN THE DEFENSE PROGRAM PRODUCTION SCHEDULES



Source: Adapted for use by the author from the War Production Board, *Wartime Production Achievements and the Reconversion Outlook: Report of the Chairman* (Washington, D.C.: Government Printing Office, October 9), 1945, p. 11, World War II Administrative Histories (New Haven, CT: Research Publications, Inc.), microfilm, reel 371.

Similarly, estimated spending for 1943 far exceeded U.S. industrial potential after the military Services submitted expenditure requests totaling $110 billion.[41] These estimates highlighted a significant gap between procurement needs and U.S. military production capacity and prompted efforts to coordinate procurement priorities and curtail commercial production. To accomplish this, Roosevelt established the WPB in January 1942 and appointed Donald Nelson as its chairman.

Production growth was modest during the first half of 1942 but rapidly expanded by the end of the year as wartime policies took effect. By 1944, the conversion challenges of prior years had largely been overcome. As supply chains stabilized and military procurement demands began to ease, Nelson turned his attention to the emerging challenge of postwar reconversion. This transition was driven by improving strategic conditions overseas. Germany's war efforts in North Africa and on the Eastern Front severely weakened the Wehrmacht's ability

41 Fesler et al., *Industrial Mobilization for War*, p. 363; and U.S. Civilian Production Administration, "Minutes of the War Production Board, January 20, 1942, to October 9, 1945," 1946, p. 172, World War II Administrative Histories (New Haven, CT: Research Publications, Inc.), microfilm, reel 375. This figure was later reduced to approximately $80 billion after multiple rounds of revision by the WPB and the services, which was considered "within the realms of possible accomplishment."

to repel the Allied invasion of Normandy, and the United States had launched major offensives to dismantle Japanese forces in the Pacific. Although victory was far from certain, the shifting momentum of the war made it increasingly necessary for U.S. officials to plan the transition to a peacetime economy.

Reconversion was seriously addressed for the first time during WPB meetings on July 4 and 11, 1944, when four initial policies were established to prepare industry for the transition: the termination of orders limiting the use of aluminum and magnesium, permissions for businesses to produce and test commercial models for postwar use, permissions for retooling to civilian production, and the "spot-authorization order," which enabled the authorization of limited consumer goods production by regional WPB directors.[42] These orders were intended to prepare industry for broader reconversion efforts in the future and to prevent mass unemployment as defense spending drew down; however, they soon became a source of controversy. Opponents of the policies within the WPB and the armed Services felt that reconversion efforts were premature, given the military's ongoing offensive operations overseas and the potential for the policies to create a false sense of security among the American public.[43] The proposals also faced strong opposition from Paul V. McNutt of the War Manpower Commission, who contended that reconversion policies would generate additional employment opportunities in oversaturated labor markets and hinder the transfer of workers from these areas to regions where manpower shortages still existed.[44] The conflict over Nelson's reconversion orders was only resolved after James F. Byrnes, director of the Office of War Mobilization, intervened and reached an agreement between Nelson and McNutt to implement the policies in a staggered manner throughout the summer of 1944.[45]

Production in 1945 was characterized by three distinct phases (see Figure 2): maximized war production (January to March), adjusting production to a one-front war (April to August), and complete demobilization following V-J Day.[46] Projected defense expenditures rose to $64.6 billion early in the year due to intensified German resistance at the Battle of the Bulge.[47] As a result, Nelson's reconversion efforts were suspended, and consumer goods production remained restricted by the WPB at the beginning of the year. These trends were reversed upon Germany's imminent collapse. In coordination with the armed Services, the WPB began revising procurement schedules and scaling back select contracts, which

42 U.S. Civilian Production Administration, "Minutes of the War Production Board," pp. 341–346; and Donald M. Nelson, *Arsenal of Democracy: The Story of American War Production* (New York: Harcourt Brace and Company), pp. 401–402.

43 Fesler et al., *Industrial Mobilization for War*, pp. 739, 802–805.

44 Ibid., *Industrial Mobilization,* p. 804.

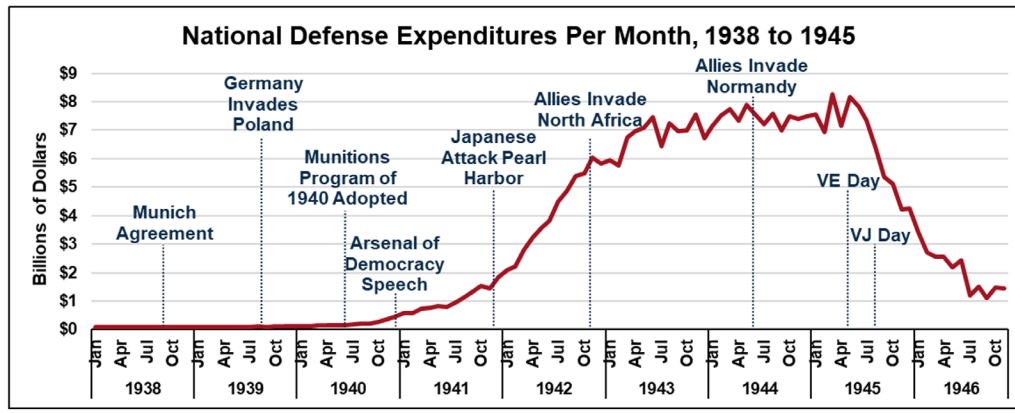
45 Ibid., pp. 801–806.

46 Ibid., p. 857.

47 Ibid., p. 858; and U.S. Civilian Production Administration, "Minutes of the War Production Board," p. 378.

resulted in a defense expenditure of only $44 billion for the second half of 1945 (in terms of annual spending).[48]

FIGURE 2: U.S. GOVERNMENT EXPENDITURES FOR WAR ACTIVITIES, 1938–1945



Source: Tyler Hacker, *Arsenal of Democracy: Myth or Model? Lessons for 21st-Century Industrial Mobilization Planning* (Washington, DC: Center for Strategic and Budgetary Assessments, May 2025), p. 19.

The reduced production requirements enabled the government to eliminate certain civilian controls to alleviate economic pressure on the American population. Following V-J Day, the WPB quickly revoked most wartime restrictions on the production of civilian goods.[49]

From July 1940 to July 1945, the United States produced 296,429 aircraft; 71,062,000 displaced tons of naval ships; 2,681,052 machine guns; 88,410 tanks; and numerous other munitions, textiles, and supplies.[50] These exceptional feats outstripped production in both Germany and Japan and undoubtedly sustained the United States and its allies to victory during World War II. This was achieved even though the United States encountered considerable obstacles in initiating and executing the industrial conversion process. The next chapter examines the principal obstacles to industrial conversion within the automotive industry and draws on the historical record to highlight the solutions that enabled that sector to fulfill its wartime production requirements.

48 U.S. Civilian Production Administration, "Minutes of the War Production Board," pp. 399–412; and Fesler et al., *Industrial Mobilization for War*, pp. 859–860.

49 Fesler et al., *Industrial Mobilization for War*, pp. 860–862.

50 Gropman, *Mobilizing U.S. Industry in World War II*, Appendix A; William Fitzgerald, *The Ordnance Program under the War Production Board and Predecessor Agencies* (Washington, DC: WPB, 1944), pp. 141–145.

CHAPTER 3

Challenges to Industrial Conversion in the Automotive Industry

> On an overall industry basis, there is no question whatever that the automobile industry has the ablest and most resourceful production talent in the country. Thus far, we are not benefiting from this industry's talent to anywhere near the extent that we should.
>
> —Paul Holden, Industrial Advisor to the Office of Production Management, May 28, 1941[51]

> I am convinced that if we are going to get production where it must be during the coming months that it is essential that we utilize for defense purposes a substantial part of the large durable goods factories in America that are now manufacturing items to meet consumer needs.
>
> —President Franklin D. Roosevelt to William S. Knudsen, July 9, 1941[52]

On the eve of war, the American passenger car industry was among the largest and most technologically advanced manufacturing sectors in the world. It vastly outproduced and outperformed its foreign counterparts, manufacturing 2,508,467 units compared to the rest of the world's 1,487,856 in 1938.[53] The industry employed 516,062 workers and sold a staggering 3,717,385 units in 1940 alone.[54] The three largest firms at this time were General

51 Carlyle Sitterson, *The Automotive Industry in War Production, May 1940 to December 1943* (Washington, D.C.: Policy Analysis and Records Branch, WPB, 1944), p. 6, World War II Administrative Histories (New Haven, CT: Research Publications, Inc.), microfilm, reel 355.

52 Ibid., p. 8.

53 John Bell Rae, *The American Automobile Industry* (Boston: Twayne Publishers, 1984), p. 174.

54 Hyde, *Arsenal of Democracy*, p. 189; and Alan Clive, *State of War: Michigan in World War II* (Ann Arbor: University of Michigan Press, 1983), p. 22.

Motors, Chrysler, and Ford. The "big three" were followed by six smaller companies: Plymouth, Buick, Pontiac, Dodge, Oldsmobile, and Studebaker.[55]

These companies had weathered the challenges of the Great Depression by establishing many car-buying norms that are still in use today (such as trade-ins and monthly installment payments) and by producing more affordable models through mass-production techniques.[56] The latter capability made the industry attractive to the U.S. government for defense projects. Its large engineering teams and mass-production expertise could be leveraged to adapt military design specifications and expedite production schedules. The auto industry also benefited from strong advocacy by Knudsen, who had Roosevelt's ear and had served as president of General Motors before joining NDAC. As a result, the U.S. strategy to convert commercial industries relied on the automotive industry to meet the War Department's defense production goals (see Table 1).

TABLE 1: VALUE OF MILITARY ITEMS PRODUCED BY THE AUTOMOTIVE INDUSTRY

Items	Value	Percent of Total
Aircraft, aircraft subassemblies and parts	$11,216,487,000	38.7%
Military vehicles and parts	$8,612,173,000	29.7%
Tanks and parts	$3,808,626,000	13.1%
Marine equipment	$1,944,533,000	6.7%
Guns, artillery and parts	$1,587,736,000	5.5%
Ammunition and components	$909,335,000	3.1%
All other war products	$907,495,000	3.1%

Source: Automobile Manufacturers Association. *Freedom's Arsenal: The Story of the Automotive Council For War Production* (Detroit: Automobile Manufacturers Association, 1950), p. 193.

The automotive industry made a vital contribution to the overall war effort, but its full conversion required overcoming several challenges. Most notably, no centralized authority existed that could override corporate financial interests during peacetime, which allowed commercial automobile production to continue well after defense needs should have taken priority. Second, the automotive industry faced manufacturing limitations in adaptable factory space and machine tooling that delayed the conversion process. Finally, the lack of clearly defined War Department requirements, coupled with the high demand for emerging and complex military capabilities, forced the industry to operate under shifting requirements and compressed timelines.

55 V. Dennis Wrynn, *Detroit Goes to War: The American Automobile Industry in World War II* (Osceola, WI: Motorbooks International, 1993), p. 17.

56 Ibid., p. 17.

Lack of Authority and the Limits of Mobilization Through Negotiation

The absence of a robust and centralized organization charged with overseeing national mobilization efforts in the prewar period prevented the U.S. government from effectively setting priorities, regulating commercial production during peacetime, and overcoming prevailing corporate financial interests that hindered industrial conversion. The fundamental belief among many political leaders at the time was that private industry would voluntarily shoulder the burden of America's defense production. Although the business community demonstrated patriotic enthusiasm for mobilization efforts, many industries remained focused on more profitable commercial production. American car manufacturers were no exception, and they had little incentive to produce defense goods. The industry had only recently emerged from the Great Depression and was experiencing a recovery in sales between 1939 and 1941.[57] The automakers also viewed defense contracts as much riskier than their consumer business. A transition to defense production would require substantial investments in new machine tools, workforce training, and factories, none of which would have much applicability to postwar commercial manufacturing. [58]

These corporate sentiments posed a challenge for Knudsen during his tenure in both NDAC and OPM. The automakers' continued production of commercial cars led to shortages of the raw materials and machine tools that were critical for the war effort. The automakers consumed more steel, gasoline, rubber, plate glass, nickel, and lead than any other civilian industry in 1940.[59] Additionally, only 8 percent of the industry's workforce had been converted to defense production by that time.[60] The continued diversion of labor and materials to commercial output threatened to derail the mobilization plan. Time was also a critical factor, because delays in conversion pushed production goals further out of reach for the years ahead.

Neither NDAC nor OPM had the organizational authority to address these issues effectively. NDAC could coordinate voluntary cooperation between industry and government but could not truly enforce priorities, allocate resources, or direct industrial conversion. Consequently, peacetime mobilization efforts lacked direction at the national level under its supervision, which led to direct coordination between the procurement divisions of the military Services and private industry. OPM achieved more success in its attempts to regulate the industry, though only after a protracted dispute over the extent of its authority. On paper, it had the full power to create plans for national mobilization and "to take all lawful action necessary to carry out such plans."[61] In reality, OPM had no more authority than NDAC when it was

57 Hyde, *Arsenal of Democracy*, p. 2. Sales increased from two million units in 1938 to 3.8 million in 1941.

58 Clive, *State of War*, p. 19.

59 McCauley, *Conversion of the Consumer Durable Goods Industry*, p. 9.

60 Sitterson, *The Automotive Industry in War Production*, p. 11.

61 Fesler et al., *Industrial Mobilization for War*, p. 95.

established, and it did not receive jurisdiction to allocate materials for private industry until that was delegated by Roosevelt a full eight months later. OPM also lacked oversight of military requirements and the contracting process, which prevented it from translating these into production schedules.[62]

Solution: Strengthened Government Authority and Organizational Capacity

Unchecked commercial production was addressed by gradually expanding government regulation and improving centralized coordination of national resources under OPM and the WPB. As OPM's authorities expanded, it implemented a series of curtailment and resource prioritization policies to curb commercial production and resolve emerging material shortages. These policies were refined and implemented on a much broader scale under the WPB after the attack on Pearl Harbor.

The curtailment of commercial production played a key role in shifting the automotive industry to wartime manufacturing during the defense period. Despite its limited authority, OPM spearheaded the first substantial curtailment of the industry in 1941. Predictably, many automakers were unhappy with the policy. They argued that arbitrary curtailment policies would lead to widespread unemployment, create resentment toward the government among workers, and disorganize defense production efforts in the long term.[63] Knudsen and his team acknowledged the risks associated with such a policy but understood that unchecked civilian production would be more damaging to the war effort.

To combat industry resistance, Knudsen gathered representatives from across the automotive industry on April 17, 1941, and proposed a 20 percent cutback in passenger car production for a six-month period beginning on August 1.[64] Thanks to Knudsen's persistent negotiations and strong industry connections, the industrialists largely agreed to the curtailment. Industry resistance was also minimized by the fact that the curtailment policy was temporary and based on record-high production rates over the past 12 months, thereby minimizing its impact on the industry's actual automobile sales. After extensive negotiations, the curtailment was enacted based on company size: Ford, General Motors, and Chrysler cut production by 21.5 percent; medium-sized companies by 15 percent; and small businesses were exempt.[65]

62 Ibid., p. 121; and Smith, *The Army and Economic Mobilization*, pp. 266–269. The OPM tried to mitigate this by requiring the services to clear all contracts of more than $50,000, but this process was so cumbersome that OPM later changed it to $1,000,000. These processes did little to affect the resource allocation problem.

63 Sitterson, *The Automotive Industry in War Production*, p. 4; and Fesler et al., *Industrial Mobilization for War*, pp. 190–192.

64 Sitterson, *The Automotive Industry in War Production*, p. 5; and Fesler et al., *Industrial Mobilization for War*, pp. 190–192.

65 Fesler et al., *Industrial Mobilization for War*, p. 191.

OPM was reluctant to implement a more aggressive curtailment policy on the automotive industry (and the broader private sector) due to concerns that cutting commercial production would trigger widespread unemployment before defense contracts were fully realized. Furthermore, OPM lacked a comprehensive understanding of the nation's overall defense requirements, and its members were hesitant to impose restrictions that could significantly impact the economy without first understanding the nation's defense needs. Despite these concerns, the Office of Price Administration and Civilian Supply (OPACS), which was considered a competing agency to OPM, viewed the voluntary reduction as insufficient and announced its own mandatory curtailment policy of 50 percent without consulting OPM staff.[66]

The conflicting OPM and OPACS curtailment policies stemmed from their unclear and overlapping authorities. OPACS was responsible for regulating prices and managing civilian production, and OPM dealt primarily with defense production; however, it was difficult to distinguish between the two when private industry was already involved in defense manufacturing.[67] After much debate between the two agencies, Knudsen announced a mandatory 43 percent curtailment from August 1941 to July 1942.[68] The automotive curtailment was the first of many "limitation and conservation" orders aimed at conserving resources, freeing up factory space, and encouraging industries to transition to defense production. These curtailment policies created a significant production vacuum for manufacturers and forced them to shift to defense work to stay in business.[69] By the end of 1942, there were approximately 60 such orders in place, covering nearly 1,000 consumer products.[70]

Beyond curtailment, the government recognized the need to establish resource allocation priorities among the Army, Navy, and private industry to ensure adequate raw materials and production capabilities were reserved for the most pressing defense contracts. A priorities system was first developed by the Army and Navy Munitions Board (ANMB) on June 17, 1940.[71] Soon after, Congress enacted the National Defense Expediting Act (also known as the Naval Expediting Act), which empowered the president to prioritize materials for

66 Sitterson, *The Automotive Industry in War Production*, p. 10; and U.S. Civilian Production Administration, "Minutes of the Council of the Office of Production Management, December 21, 1940, to January 14, 1942," 1946, p. 45, World War II Administrative Histories (New Haven, CT: Research Publications, Inc.), microfilm, reel 373.

67 McCauley, *Conversion of the Consumer Durable Goods Industry*, p. 13.

68 Sitterson, *The Automotive Industry in War Production*, p. 10; Hyde, *Arsenal of Democracy*, p. 21; and Fesler et al., *Industrial Mobilization for War*, p. 196. Sitterson identifies a 50 percent curtailment, but both Hyde and Fesler et al. identify 43 percent.

69 McCauley, *Conversion of the Consumer Durable Goods Industry*, p. 16.

70 Irene Walker, *Consumer Durable Goods: Policies and Programs, 1940–1945*, vol. 2 *Materials and Products, Industrial Mobilization for War: A History of the War Production Board and Predecessor Agencies, 1940–45* (Washington, D.C.: U.S. Civilian Production Administration, May 1947), p. 13, World War II Administrative Histories (New Haven, CT: Research Publications, Inc.), microfilm, reel 397.

71 Smith, *The Army and Economic Mobilization*, p. 508; and McCauley, *Conversion of the Consumer Durable Goods Industry*, p. 87.

defense contracts over commercial production. Roosevelt did not initially delegate this authority to a specific agency, so ANMB's first priorities system was designed primarily to address resource competition between the Services. It operated on a voluntary basis for commercial manufacturers.[72]

Roosevelt finally delegated his authority to NDAC on October 21, 1940, as resource shortages began to rise across the country. With its new power, NDAC quickly developed a series of regulations governing a new priorities system. However, the ANMB and the individual Services still maintained control over the most critical administrative functions related to resource prioritization. These regulations largely sidelined NDAC in the priorities process, allowing the Services to implement independent procurement strategies without much consideration of their impact on the national economy or critical resource supplies.[73] NDAC retained the authority to implement mandatory distribution controls over the private sector, though it never exercised that authority.[74]

These factors reduced the overall effectiveness of the priorities system under NDAC, and a revised program was implemented once OPM assumed responsibilities for mobilization planning. This revised system reconsolidated some power under the agency and extended the priorities system to select segments of civilian industry; however, much of the day-to-day procurement practices remained with the individual Services. Additionally, OPM's effectiveness was undermined by jurisdictional issues with OPACs. As a result, Roosevelt established the Supply Priorities and Allocations Board (SPAB) as an entity independent from both OPM and OPACS on August 28, 1941. This board included leaders from various defense organizations who were tasked with setting allocation policies for military use, Lend-Lease aid, and civilian production, which various federal agencies then implemented across the government.[75] The transparent authority structure and improved interagency coordination enabled SPAB to adopt a more assertive and unified approach to resource allocation. Although overall procurement responsibilities remained in the hands of the Services, the SPAB established policies that mandated restrictions on civilian manufacturers for all essential components and raw materials.[76]

Despite the achievements in curtailment and resource prioritization policies, neither OPM nor SPAB had the organizational influence, capacity, or authority to effectively mobilize the entire economy. The government's authority issue was ultimately resolved when the United States entered the war and Roosevelt was given broad executive powers under the First War Powers Act. By establishing the WPB, Roosevelt created a more robust and centralized agency endowed with extensive authority to restrict commercial production and control

72 Smith, *The Army and Economic Mobilization*, pp. 509–510; and Fesler et al., *Industrial Mobilization for War*, p. 64.

73 Koistinen, *Arsenal of World War II*, pp. 66–67.

74 Ibid., pp. 66–67.

75 Nelson, *Arsenal of Democracy*, p. 159; and Fesler et al., *Industrial Mobilization for War*, p. 89.

76 Nelson, *Arsenal of Democracy,* p. 165.

resources on a broader scale. The WPB addressed commercial automobile production in its very first meeting and directed that no additional passenger cars would be manufactured once the industry fulfilled its January quotas.[77] This significant turning point in the conversion process compelled automakers to quickly reorient to wartime manufacturing. Defense work in the industry grew by 46 percent in the first two months after the curtailment, and total production costs reached $193 million by April 1942.[78] By July 1942, an estimated 95.1 percent of the industry was focused on defense production.[79]

The WPB also reformed the priorities system by implementing the Production Requirements Plan (PRP) and the Controlled Materials Plan (CMP). The PRP, developed in 1942, required manufacturers to submit their material needs directly to the WPB on a quarterly basis for allocation.[80] The PRP proved too cumbersome and was replaced in 1943 by the CMP, which allotted specific quantities of essential resources and equipment to the armed Services.[81] These allocations were then distributed by the Services to private manufacturers based on procurement needs. Although the armed Services still maintained control over the procurement process, the CMP enabled the WPB to oversee the national supply of raw materials, ensuring that resource allocations for the Services and the private sector were consistent with the available nationwide supply. These reforms addressed many of the issues identified in the priorities system established under OPM. They were only made possible by WPB's larger staff and its authority to oversee policy for both the military Services and private industry. Despite facing periodic shortages during the war, the automotive industry likely avoided more severe disruptions to production due to the successful implementation of the reformed priorities system under the CMP.

Absence of War Production Infrastructure and Tooling

The absence of specialized tooling and production facilities was another major obstacle to the automotive industry's conversion. Whenever feasible, the government tried to use existing civilian manufacturing plants and machine tools for war production to save time and valuable resources for the overall war effort (see Figure 3). Many automotive plants converted existing space to produce items similar to passenger cars, such as jeeps and trucks.

77 U.S. Civilian Production Administration, "Minutes of the War Production Board," p. 1.

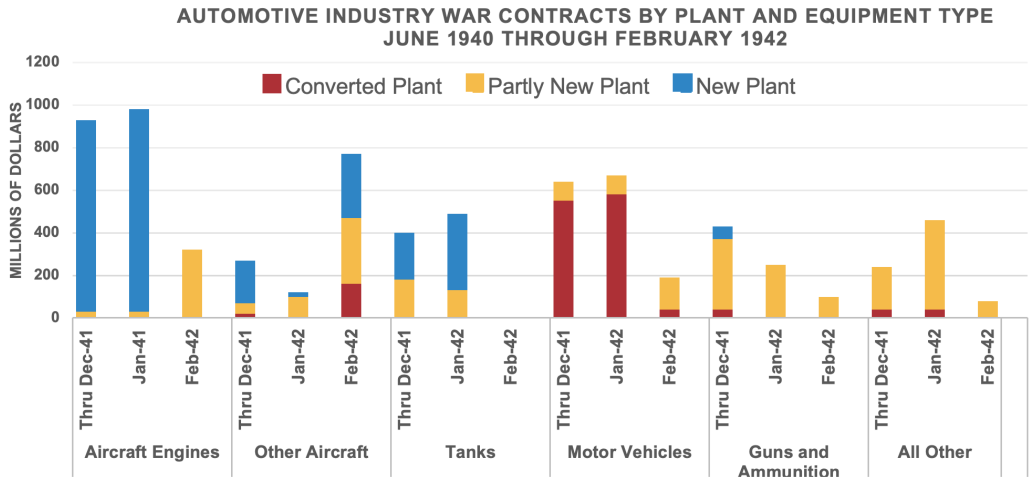
78 Sitterson, *The Automotive Industry in War Production*, p. 19.

79 Ibid., p. 19

80 Smith, *The Army and Economic Mobilization*, pp. 557–558; and Fesler et al., *Industrial Mobilization for War*, pp. 456–457.

81 Smith, *The Army and Economic Mobilization*, p. 571; and Fesler et al., *Industrial Mobilization for War*, p. 491.

FIGURE 3: AUTOMOTIVE INDUSTRY WAR CONTRACTS BY PLANT AND EQUIPMENT TYPE, 1940–1942



Source: Adapted for use by the author from Carlyle Sitterson, *The Automotive Industry in War Production, May 1940 to December 1943* (Washington, D.C.: Policy Analysis and Records Branch, WPB, 1944), p. 31, World War II Administrative Histories (New Haven, CT: Research Publications Inc.), microfilm, reel 355, Inc.

These plants were also used to produce individual components for later assembly into larger and more complex end items, like tanks and aircraft.[82] Despite extensive commercial factory conversion, there was considerable debate over the degree to which the auto industry's existing infrastructure could be adapted for wartime production. The automakers argued that many of their factories were ill suited to producing or assembling larger pieces of military equipment, which required enormous reinforced factories that were uncommon within the industry.[83] For example, tank production required a completely different factory layout and significantly more machine tools than automobiles, and most companies were unwilling to accept the financial risk required to construct new plants for these needs.[84]

Early estimates of total adaptable plant capacity within the industry varied from 15 percent to 50 percent, with the auto industry's own estimates at the low end of this range.[85] Undersecretary of War Robert Patterson later testified before the Special Committee Investigating the National Defense Program (also known as the Truman Committee) that the automakers provided inaccurate data on factory convertibility early in the conversion process, suggesting that a larger portion of the industry could have been transitioned if more reliable figures had been available.[86] Although there is no direct evidence that this was

82 Fitzgerald, *The Ordnance Program*, p. 3; and Hyde, *Arsenal of Democracy*, pp. 75–77, 122, 127.

83 Hyde, *Arsenal of Democracy*, p. 11.

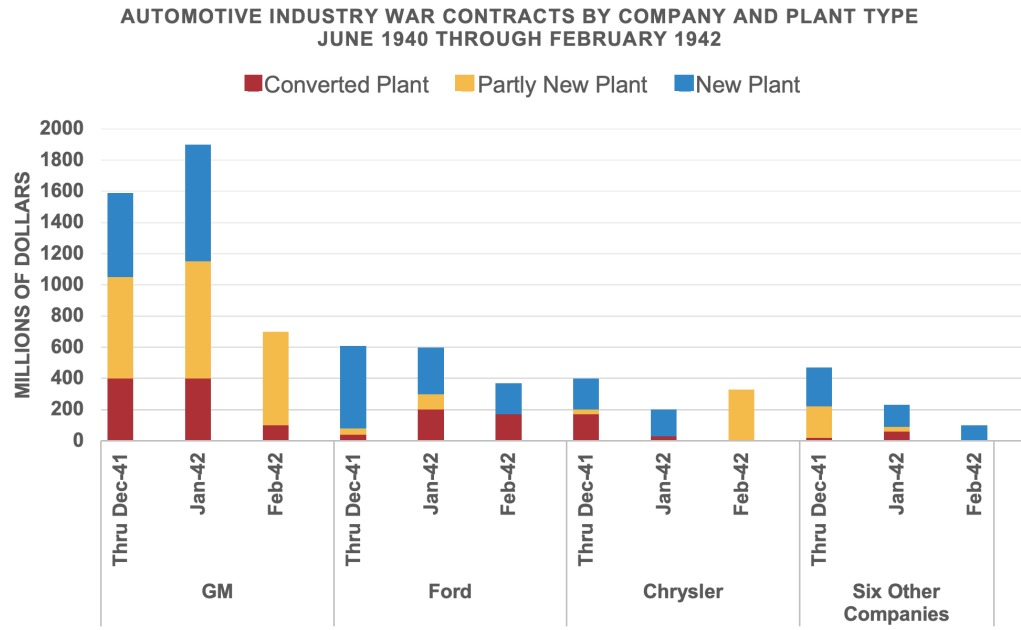
84 Thomson and Mayo, *The Ordnance Department Procurement and Supply*, p. 227.

85 Sitterson, *The Automotive Industry in War Production*, p. 6.

86 Patterson, *Arming the Nation for War*, p. 247.

deliberate, the committee noted that automakers changed their stance on the convertibility of their facilities only after curtailment policies rendered passenger car production impossible.[87] The U.S. government was thus forced to use newly built facilities for most of the automotive industry's early defense work (see Figure 4).

FIGURE 4: AUTOMOTIVE INDUSTRY WAR CONTRACTS BY COMPANY AND PLANT TYPE, 1940–1942



Source: Adapted for use by the author from Carlyle Sitterson, *The Automotive Industry in War Production, May 1940 to December 1943* (Washington, D.C.: Policy Analysis and Records Branch, WPB, 1944), p. 31, World War II Administrative Histories (New Haven, CT: Research Publications, Inc.), microfilm, reel 391.

By October 1941, 62 percent of the defense work by automotive companies was scheduled for production in new facilities funded and constructed by the government, with the remaining 38 percent planned for production in converted automotive facilities.[88]

Machine tool shortages also posed a substantial obstacle to conversion. Automakers were tasked with producing complex military equipment that required hundreds of specialized tools, many of which were not readily available. Although some existing tools could be adapted to defense use, the industry often needed entirely new sets that had never been designed or manufactured at scale. For example, Ford had to design 8,128 new machine tools just to produce aircraft engines.[89] Similarly, Chrysler required over 7,000 machine tools to

87 Special Committee Investigating the National Defense Program, *Additional Report of the Special Committee Investigating the National Defense Program* (Washington, D.C.: U.S. Government Print Office, 1942), p. 35.

88 Sitterson, *The Automotive Industry in War Production*, p. 11.

89 Hyde, *Arsenal of Democracy,* p. 55.

produce aircraft engines but had only three-quarters of those tools available at its Dodge plant in Chicago by late 1943.[90]

These examples were not exclusive to the automobile industry. There was an immediate increase in demand for machine tools across virtually every industry involved in defense production during the prewar mobilization period. The sudden influx of tooling orders quickly overwhelmed the machine tool industry with unprecedented production demand that it was not equipped to meet. In 1940, most of the machine tools used in industry came from only 200 small businesses that employed fewer than 100 employees on average.[91] Many of these firms were hesitant to expand their operations in the prewar period over fears of bankruptcy that could result from developing unused excess production capacity.[92]

The small size of the industry, combined with a sudden nationwide increase in demand, led to machine tool delivery times ranging from six to 12 months.[93] These long delays were exacerbated by a significant lag between the date these machine tools were needed for production and when they were ordered. Subcontracts for tools were typically awarded after the finalization of the primary contract for the end item.[94] As a result, many machine tools were not ordered until they were immediately needed to produce military items.[95] The machine tool industry, concerned about potential order cancellations, was generally reluctant to manufacture surplus inventory for immediate distribution.

The government made substantial efforts to locate existing machine tools across the country to remedy the shortage, but progress was impeded by businesses that hoarded tools for their own manufacturing needs.[96] Often, these machine tools went unused in factories when they were needed for defense production at other plants, or they were used for lower-priority production requirements.[97]

Overall, the absence of adaptable preexisting infrastructure and specialized tooling created significant bottlenecks and delays in defense manufacturing. Before production could commence, significant tasks needed to be completed: new plants had to be constructed, factory layouts designed, machinery ordered, and workers trained.[98] The government

90 Ibid., p. 69.

91 Herman, *Freedom's Forge*, p. 147.

92 Patterson, *Arming the Nation for War*, p. 50.

93 McCauley, *Conversion of the Consumer Durable Goods Industry*, p. 100.

94 Virginia Turrell, *Industrial Mobilization for War: History of the War Production Board and Predecessor Agencies 1940–1945,* vol. 2, *Materials and Products,* pt. 2, *Industrial Equipment (*Washington, D.C.: U.S. Civilian Production Administration, 1946), p. 23, World War II Administrative Histories (New Haven, CT: Research Publications, Inc.), microfilm, reel 391.

95 Ibid., pp. 13, 23.

96 Patterson, *Arming the Nation for War*, p. 50.

97 Turrell, *Industrial Mobilization for War,* p. 41.

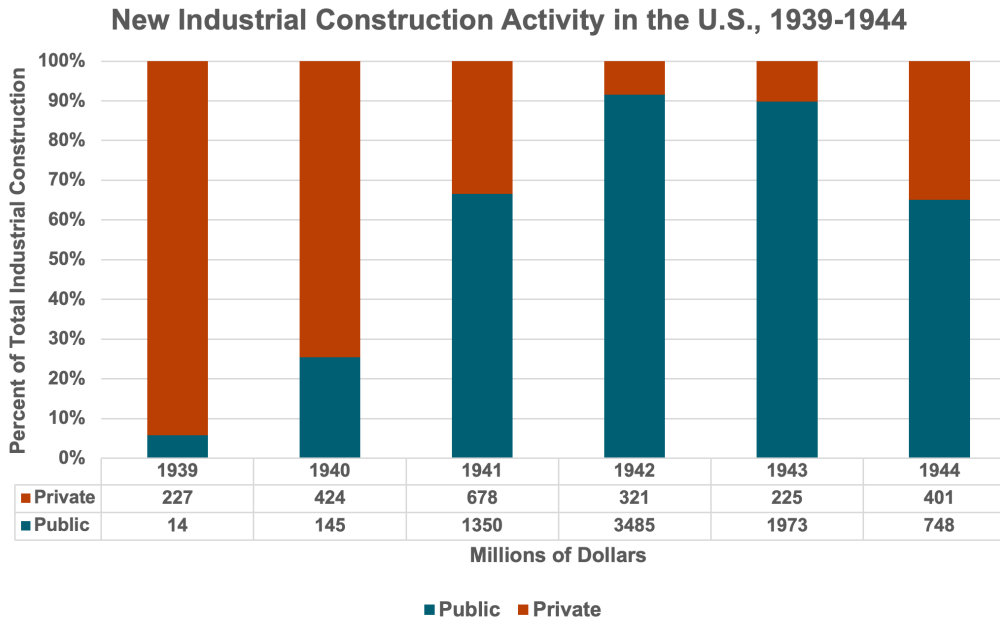
98 Sitterson, *The Automotive Industry in War Production*, p. 17.

accelerated this process by directly investing in the facilities and tools necessary to meet defense contracts.

Solution: Government Investment in Infrastructure and Tooling

Both the automotive industry and the machine tool industry were hesitant to invest in increased defense production capacity during the prewar period due to uncertainty over the demand and the duration of defense contracts at that time. Additionally, the voluntary nature of industrial conversion made it difficult for the government to use existing capacity before the implementation of widespread consumer good curtailment policies. These factors prompted the U.S. government to remedy nationwide shortages in plant space and machine tools through a series of federally funded programs designed to kickstart production and mitigate the private sector's financial risks (see Figure 5).

FIGURE 5: INDUSTRIAL CONSTRUCTION ACTIVITY IN THE U.S., 1939–1944



Source: Adapted for use by the author from the WPB, *Wartime Production Achievements and the Reconversion Outlook*, Report of the Chairman, October 9, 1945, p.33.

In the automotive sector, the U.S. government funded the establishment of entirely new government-owned, contractor-operated (GOCO) facilities to circumvent the challenge of convertibility. GOCO plants were financed by the government and leased to private businesses to operate for a fixed fee. The Defense Plant Corporation (DPC) was established on August 22, 1940, to provide funding for these projects and financed multiple plants for the automotive industry between 1940 and 1942 (see Table 2). Of the $1.53 billion the

DPC sponsored for facilities through the War Department, $767 million was directly tied to automakers.[99]

TABLE 2: DPC FACILITY CONSTRUCTION PROJECTS SPONSORED BY THE WAR DEPARTMENT

Company	Location	Cost to U.S. Government, 1945	Approximate Cost in 2025 Dollars
Chrysler (Dodge)	Chicago, IL	$173,647,431	$3,111,771,610
Basic Magnesium	Las Vegas, NV	$132,695,356	$2,377,908,151
General Motors (Chevrolet)	Buffalo, NY	$120,055,095	$2,151,393,972
General Motors (Buick)	Melrose Park, IL	$110,009,223	$1,971,371,387
Ford Motors	Willow Run, MI	$86,595,661	$1,551,799,055
Studebaker	South Bend, IN	$77,724,127	$1,392,820,673
Wright Aeronautical	Lockland, OH	$74,859,211	$1,341,481,219
Wright Aeronautical	Woodridge, NJ	$65,029,598	$1,165,334,008
General Motors (Allison)	Speedway City, IN	$62,541,329	$1,120,744,090
Ford Motors (Rouge)	Dearborn, MI	$59,800,671	$1,071,631,346
Dow Magnesium	Velasco, TX	$56,514,718	$1,012,746,886
Mathieson Alkali Works	Lake Charles, LA	$48,867,624	$875,710,536
Dow Magnesium	Marysville, MI	$42,228,327	$756,733,965
Continental Aviation	Detroit, MI	$41,971,682	$752,134,873
General Motors (Fisher Body)	Flint, MI	$39,156,924	$701,694,253
Packard Motor	Detroit, MI	$38,256,297	$685,554,967
Curtiss-Wright	Cheektowago, NY	$36,386,370	$652,045,771
Sperry Gyroscope	North Hempstead, NY	$36,380,123	$651,933,825
Wright Aeronautical	Paterson, NJ	$34,113,760	$611,320,474
North American Aviation	Grand Prairie, TX	$32,604,623	$684,276,655
Standard Steel Spring	Madison, IL	$30,231,525	$541,750,607
Curtiss-Wright	Columbus, IN	$29,608,849	$530,592,219
Thompson Aircraft Products	Euclid, OH	$29,123,338	$521,891,834
Higgins Aircraft	New Orleans, LA	$28,719,042	$514,646,828
Boeing Airplane	Wichita, KS	$26,781,232	$479,921,165
American Steel Foundries	East Chicago	$26,083,414	$467,146,227
Total		**$1,539,985,550**	**$27,696,356,596**

Major DPC Facilities for the Automotive Industry

Source: Adapted for use by the author from R. Elberton Smith, *The Army and Economic Mobilization* (Washington, D.C.: Office of the Chief of Military History, Department of the Army, 1959), p. 496. 2025 dollar costs were calculated using https://www.usinflationcalculator.com/

The DPC also financed the machine tools needed for these plants and established a surplus pool of tools that could quickly be allocated to specific defense contractors based on need.[100] The surplus pool created excess inventory that was critical for remedying backlogs brought on by a sudden influx of orders.

99 Smith, *The Army and Economic Mobilization*, p. 496.

100 Hyde, *Arsenal of Democracy*, p. 41.The DPC's first large purchase of machine tools occurred in May 1941, with $235 million allocated to machine tools for defense purposes. These orders jumped to a peak of $1.361 billion in 1942.

The DPC's construction of facilities and financing of machine tools played an important role in expanding defense production. DPC contracts were largely free of bureaucratic red tape, which enabled the rapid construction of many new plants in the defense period.[101] Additionally, the established surplus pool ensured machine tools were immediately available to contractors once a need was identified. In both cases, the U.S. government underwrote the financial risk of the private sector to alleviate bottlenecks that threatened to reduce overall production output.

Military Equipment Complexity and Rapid Evolution of Designs

Finally, unclear and rapidly evolving military requirements forced private industry to operate under constantly shifting demands and tight timelines. Automakers often had to modify product designs before production could even begin due to the increased complexity of new equipment that had never been mass produced. For instance, Ford was required to accommodate 900 design changes to the B-29 bomber after its initial flight test, and Chrysler had barely started production of the M3 Lee tank before it was labeled obsolete and replaced by the M4 Sherman.[102] Design modifications only increased once new weapon systems were fielded and deficiencies were revealed in combat. Often, battlefield requirements drove the rapid development and production of entirely new weapon systems, as was the case when the Army shifted from the B-17 to the B-29 in the Pacific.[103]

Frequent design modifications often disrupted manufacturing schedules and increased production costs, as they necessitated creating new blueprints, producing new components and tools, and modifying assembly lines. Each of these steps took precious time needed to meet ever-increasing quotas from the military Services. For example, 372 modifications were made to the initial design of the B-24, which cost Ford 48,000 engineering hours and 290,000 retooling man-hours to complete.[104] Subsequent changes to the nose turret gun in 1943 cost an additional 53,456 engineering hours and 208,271 retooling man-hours.

The cumulative effects of design changes drove up costs and generated substantial price uncertainty that pushed private industry away from fixed-price contracts.[105] The Army shifted to more flexible contracting processes to alleviate private industry risk, but companies often argued that high initial prices were necessary to account for unforeseen costs.[106] These new contracting practices enabled private industry to inflate cost estimates and led to excessive waste and inefficiency.

101 Smith, *The Army and Economic Mobilization*, p. 492; and Hyde, *Arsenal of Democracy*, pp. 37–38.

102 Hyde, *Arsenal of Democracy*, p. 82.

103 Fesler et al., *Industrial Mobilization for War*, pp. 773–774.

104 Hyde, *Arsenal of Democracy*, p. 102.

105 Smith, *The Army and Economic Mobilization*, pp. 304–305.

106 Ibid., pp. 382–384.

Solution: Industrial Flexibility and Contract Process Reform

Both the automakers and the War Department developed several methods to reduce the impact of unforeseen design changes. The automotive industry's greatest assets were its inherent adaptability and engineering prowess, which it summoned time and again to minimize production delays. The most salient example is Ford's use of the block system to account for design changes to the B-24.[107] Under this system, a predetermined number of outdated aircraft were manufactured in batches before introducing new designs. This approach allowed Ford to circumvent delays by maintaining the production of existing models while arranging new production layouts for the updated designs.

The automakers also leveraged their vast engineering departments to assist the Services with new designs, streamline mass production techniques, and develop their own tools. Indeed, the exceptional engineering talent within the automotive industry was the primary reason Knudsen turned to it during the initial stages of mobilization. He believed that automakers could expand overall output by quickly resolving the engineering challenges associated with new weapon systems and then transferring the completed designs to smaller companies.[108] Knudsen's assumption was largely validated. Corporations such as Ford and General Motors leveraged their extensive resources to solve engineering and production challenges that the military design teams lacked the expertise to resolve independently.

Finally, the automakers established the Automotive Council for War Production (ACWP) after Pearl Harbor. The ACWP was a cooperative organization of manufacturers that freely shared industrial knowledge, cross-licensed patents, and publicized industry secrets to ensure maximum production across the industry.[109] Such practices ran counter to the competitive business norms at the time, but auto executives were committed to collaboration on defense work by the time war broke out. The actions of the ACWP were pivotal to harnessing the capacity of major corporations while opening avenues of production to smaller businesses across the country. By July 1943, over 22,000 companies were participating in automotive defense contracting across 43 states, many of which were smaller businesses responsible for producing components for major end items.[110]

For the military's part, the War Department attempted to standardize designs for some pieces of military equipment by removing restrictive procurement rules and regulations. Perhaps the greatest success story in standardization was truck production. Antiquated competitive bidding practices from World War I required the government to limit design specifications in contracts and to award these contracts to the lowest bidder, which often

107 Hyde, *Arsenal of Democracy*, pp. 102.

108 McCauley, *Conversion of the Consumer Durable Goods Industry*, p. 49.

109 Automobile Manufacturers Association, *Freedom's Arsenal: The Story of the Automotive Council* (Detroit: Automobile Manufacturers Association, 1950), pp. 68–70.

110 Ibid., pp. 145–146, 154.

led to multiple auto manufacturers producing different models of trucks.[111] In 1940, the War Department replaced its competitive bidding practices with a more streamlined process that allowed procurement officers to reject the lowest bid and instead negotiate contracts with other manufacturers.[112] This process enabled the U.S. Army to reduce the number of manufacturers it used for truck contracts, thereby limiting the variance of models within its fleet.

Although this case study illustrates the clearest link between changes in contract procedures and the standardization of military equipment, the reform of contracting processes extended well beyond truck production. The War Department took additional steps toward standardization by mandating design specifications and promoting the interchangeability of parts in other types of equipment, including weapon systems, aircraft engines, munitions, and tank components. The reformed contracting process also reduced the number of prime contractors used for defense work, thereby reducing variations in components and parts over time.

Although these contracting processes helped reduce variance in equipment models, they did not fully address the challenges brought on by frequent design changes. Instead, the War Department adjusted its contracting processes to transfer the cost risks associated with design changes from private industry to the government. A cost-plus-fixed-fee (CPFF) contract was frequently employed in place of fixed-price contracts when production costs were uncertain. In a CPFF contract, the government reimburses manufacturers for all approved expenses related to executing the contract, along with a fixed fee. Although CPFF contracts were controversial for allegedly fostering waste and inefficiency, they gave industry leaders the assurance needed to swiftly adapt their production processes because they knew they would be reimbursed for their costs.

The War Department also implemented contract renegotiation policies to account for potential wastefulness. Renegotiation enabled contracting officers to recover excess profits that escaped initial pricing estimates.[113] Despite the persistence of design changes throughout the war, the adaptability of the automotive industry and the government's evolving contracting practices ensured that many delays were avoided and that costs were kept in check.

111 Smith, *The Army and Economic Mobilization*, p. 253; and Thomson and Mayo, *The Ordnance Department Procurement and Supply*, pp. 266–270.

112 Smith, *The Army and Economic Mobilization*, p. 254.

113 Smith, *The Army and Economic Mobilization,* pp. 361–369.

CHAPTER 4

Tank Production Case Study

> The job experienced all the standard hardships of World War II production. The first design was scrapped before we could begin. Despite the early start made, the value of priorities for machine tools and equipment quickly melted away like snow on a hot day. Frantic calls for increased production alternated with drastic cutbacks. Disappearance of critical materials held it up. Sudden changes in design upset ability to deliver, and broke the planned flow of operations. We never once had all of the machine tools and equipment that our schedules called for.
>
> — K. T. Keller, President of Chrysler Corporation, March 17, 1948[114]

The road to industrial conversion was fraught with challenges that merit further analysis. This chapter analyzes tank production trends to provide a detailed illustration of the challenges and solutions highlighted in previous chapters.

Of the 88,410 tanks produced by the United States during World War II, over 47,203 were manufactured in facilities operated by the automotive industry.[115] U.S. tank manufacturing was almost nonexistent before the war. This was primarily due to the Army's doctrinal assumptions about the limited importance of armored warfare on the battlefield, the inherent difficulty of producing them, and limited budgets for tank production. After World War I, the Army disbanded the Tank Corps and transferred control of tanks to the Infantry Branch. The Infantry Branch focused on producing light tanks to support infantry assaults and neglected the development of tank doctrine during the interwar period. Furthermore, uncertainty over tank design specifications, combined with the high costs of production, fostered hesitation in both Congress and the Army Ordnance Department when it came

114 Thomson and Mayo, *The Ordnance Department Procurement and Supply*, p. 244. K. T. Keller's observations of tank production challenges at the Detroit Tank Arsenal.

115 Ibid., p. 242.

to investing in tank development.[116] As a result, the Ordnance Department lacked a plan for mass-producing tanks and deprioritized tank contracts in favor of other equipment in educational orders before the war.[117]

From 1920 to 1935, the Army constructed only 35 tanks, all of which were built with hand tools and had completely different designs.[118] Tank production did not gain traction until after Germany's success with blitzkrieg in 1940, as the Army only had 18 medium and 10 light tanks ready for combat at this time.[119] After Germany's tactical successes, the United States and its Allies quickly made plans to procure tanks in much greater numbers. The Army established a separate armored force on July 10, 1940, with the intent to produce thousands of tanks.[120] These factors sparked a reorientation of the automotive industry toward tank production from 1940 to 1943. The War Department first attempted to leverage locomotive manufacturers to fulfill their tank needs but later turned to the automotive industry to handle the enormous demands that required mass production expertise. This transition was primarily driven by Knudsen, who realized the locomotive industry was designed to produce only a few highly specialized pieces of equipment at a time.[121]

Knudsen first appealed to the president of Chrysler Corporation, K. T. Keller, to unleash the automotive industry's mass-production techniques on the tank problem. His plan was to build whole new plants instead of relying on Chrysler's existing infrastructure to complete the job. Tanks had never been built through mass production methods. The vastly different production layouts required for tank manufacturing cast serious doubt on whether automakers could adapt their plants. Furthermore, the surge in tank production requirements occurred at a time when Knudsen was still hesitant to curtail commercial businesses for conversion purposes.[122] Keller enthusiastically agreed to Knudsen's plan and assigned his engineers the task of providing a cost estimate for building a new tank arsenal and producing tanks at scale.

As a result, the Ordnance Department of the Army contracted with American Locomotive Company, Baldwin Locomotive, and Chrysler to produce tanks in 1940.[123] The U.S. government financed the construction of the Detroit Tank Arsenal for Chrysler's contract and

116 Ann M. Bos and Randy R. Talbot, "Enough and On Time: The Story of the Detroit Tank Arsenal," *Michigan History Magazine* 85, no. 2 (March/April 2001): p. 33; Thornton, *Tanks and Industry*, p. 13; and Thomson and Mayo, *The Ordnance Department Procurement and Supply*, p. 224.

117 Thomson and Mayo, *The Ordnance Department Procurement and Supply*, p. 224.

118 Ibid., pp. 223–224.

119 Thornton, *Tanks and Industry*, p. 14; and Thomson and Mayo, *The Ordnance Department Procurement and Supply*, pp. 226–227.

120 Thomson and Mayo, *The Ordnance Department Procurement and Supply*, p. 227.

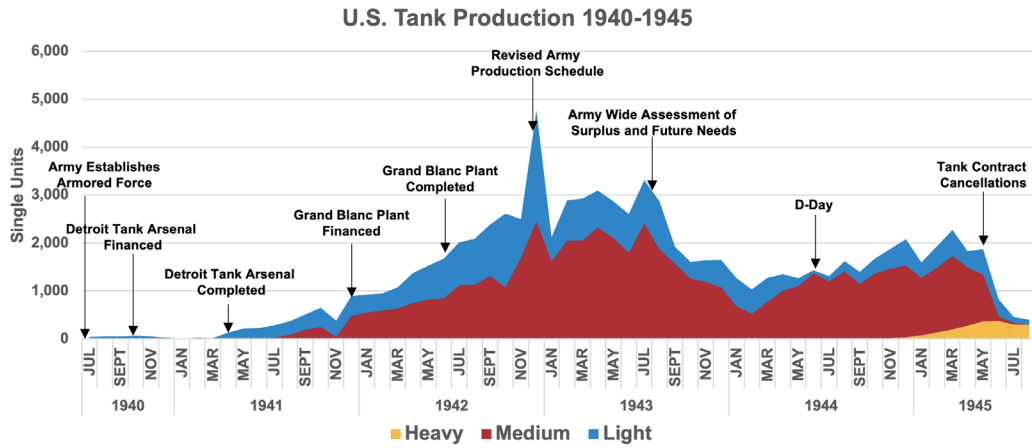
121 Ibid., p. 227

122 Thornton, *Tanks and Industry*, p. 19.

123 Hyde, *Arsenal of Democracy*, p. 120.

began construction in September. Until this arsenal became operational, the United States lacked serious production capacity and produced only 331 tanks by the end of the year (see Figure 6).[124]

FIGURE 6: U.S. TANK PRODUCTION 1940–1945



Source: Adapted for use by the author from the U.S. Civilian Production Administration, *Official Munitions Production of the United States: By Months, July 1940–August 1945* (Washington, DC: Government Printing Office, 1947), pp. 225–226. Data do not include tank conversions or specialty tanks.

The tank program expanded significantly in 1941 after Roosevelt doubled monthly tank production goals from 1,000 medium tanks to 2,000 and from 400 light tanks to 800.[125] Production rates were still minimal in the first half of 1941; however, this situation improved dramatically after the completion of the Detroit Tank Arsenal in April. Still, the Ordnance Department fell short of its monthly production goals and only produced 2,591 medium tanks and 1,461 light tanks by the end of the year.[126] Roosevelt raised tank production goals again for 1942 and 1943, but these objectives were drastically scaled back by the Army to account for actual need (see Table 3).[127] Output nevertheless soared during these years, reaching 24,997 units in 1942 and 29,497 in 1943.[128]

124 Thomson and Mayo, *The Ordnance Department Procurement and Supply*, p. 263.

125 Ibid., p. 232.

126 Ibid., p. 233.

127 Sweeney, *Industrial Mobilization for War,* vol. 2, pt. 7, p. 229.

128 Thomson and Mayo, *The Ordnance Department Procurement and Supply,* p. 263.

TABLE 3: ROOSEVELT'S TANK PRODUCTION GOALS, JANUARY 1942

	1942	1943
Heavy	500	5,000
Medium	25,000	50,000
Light	19,500	20,000
Total	45,000	75,000

Source: Adapted for use by the author from R. Elberton Smith, *The Army and Economic Mobilization* (Washington, D.C.: Office of the Chief of Military History, Department of the Army, 1959), p. 234.

The Detroit Tank Arsenal and the Fisher Body GOCO Plant were fully operational in early 1942, but a reduction in overall requirements and material shortages caused output to fall short of the president's lofty goals. By 1943, the 16 plants operated by the automotive and locomotive industries boasted a maximum capacity of 7,705 tanks per month, though actual output peaked at only 4,000.[129] At this time, production capacity began to outpace requirements as the War Department scaled back its defense program. Overproduction led to significant underutilization across several facilities and prompted the closure of four of the 16 plants by the end of 1943.[130]

By 1945, tank production had decreased by 50 percent from its peak in 1943 due to decreased demand; however, the Army made a transition to producing heavy tanks. Nearly all M26 Pershings were manufactured during this period.[131] The postponement of heavy tank production until the end of the war stemmed from the Army's underestimation of its role in combat, its decision to prioritize medium and light tanks, and the need for extensive testing and design modifications.[132]

Challenges in Tank Production

Although centralized authority was essential to wartime conversion, it was less relevant to tank production because Knudsen's strategy relied on GOCO plants rather than full industrial conversion.[133] That said, this case study illustrates how resource allocation policies and delays in curtailment contributed to material shortages that impacted tank production in 1942. Additionally, the Army's lack of early emphasis on armored warfare delayed serious tank development until 1940. This created two primary problems previously discussed: the lack of preexisting infrastructure and the evolving nature of tank design.

129 Ibid., p. 255.

130 Ibid., pp. 256–257.

131 Ibid., pp. 261–262.

132 Ibid., p. 262.

133 Thornton, *Tanks and Industry*, pp. 19–20; Thomson and Mayo, *The Ordnance Department Procurement and Supply*, p. 227; Wesley Winans Stout, *"Tanks Are Mighty Fine Things": How Chrysler's Detroit Tank Arsenal Built the Tanks That Helped Win WWII* (Detroit: Chrysler Corporation, 1946), p. 17; and Patterson, *Arming the Nation for War*, p. 39.

The Cost of Inaction: Material Shortages and Tank Production Delays

Despite the overall success of the tank program, production was hampered by material shortages in 1942. The unresolved authority divide between OPM and OPACS, along with the reluctance to challenge corporate interests, delayed curtailment policies and created raw material shortages for defense production. Steel and steel alloys—critical materials used in tank production—were affected by these delays. The automotive industry received much of the blame for growing shortages of steel and steel alloys. It consumed 18 percent of the nation's steel supply in 1939 and was a large consumer of nickel, a critical alloy used in the production of military-grade steel.[134] As curtailment policies loomed, the industry strove to increase automobile output, and the steel industry rushed to increase deliveries to automakers despite the mounting shortages that gripped the nation.[135]

Growing shortages across the country finally drove OPM to implement its curtailment and mandatory prioritization policies in the summer of 1941. It also used its authority to assign preference orders for tank manufacturing.[136] These preference orders gave priority to tank manufacturers over other contractors for the acquisition of materials and key components. Yet OPM's early inaction in confronting material shortages, combined with the inefficiency of its priorities system, created ripple effects in tank production that would not be resolved until 1943. Nine-tenths of tank components used high-grade steel strengthened with additional alloys to meet military design specifications. The Ordnance Department was forced to alter the composition of many of these parts to include fewer alloys (see Figure 7).[137] Fortunately, these conservation measures did not greatly impact the ballistic quality of tank armor or the reliability of internal components.

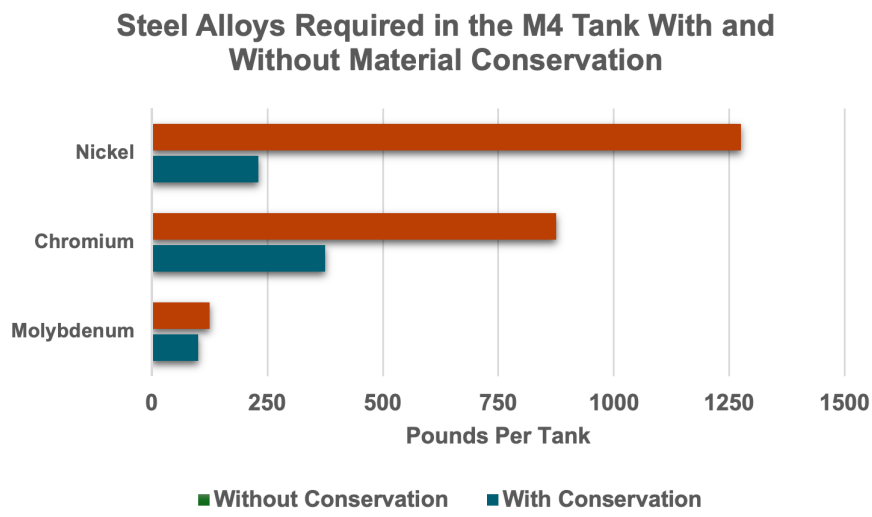
134 Hyde, *Arsenal of Democracy*, p. 21; and Patterson, *Arming the Nation for War*, p. 245.

135 Fesler et al., *Industrial Mobilization for War*, p. 193.

136 Sweeney, *Industrial Mobilization for War*, vol. 2, pt. 7, p. 269.

137 Thomson and Mayo, *The Ordnance Department Procurement and Supply*, p. 238; and Constance McLaughlin Green and Peter Roots, *The Ordnance Department: Planning Munitions for War* (Washington, D.C.: Office of the Chief of Military History, Department of the Army, 1955), pp. 480–485.

FIGURE 7: STEEL ALLOYS CONSERVATION IN MEDIUM (M4) TANKS



Source: Adapted for use by the author from Peter Roots, *The Ordnance Department: Planning Munitions for War* (Washington, D.C.: Office of the Chief of Military History, Department of the Army, 1955), p. 485

Alloy steel shortages had their greatest impact on tank production in November 1942, when over 10,000 tanks were not finished on time due to a shortage of steel tank tracks.[138] Furthermore, material shortages in nickel, copper, aluminum, and rubber contributed to the Army's decision to reduce its tank requirements in the fall of 1942. Although these cutbacks largely aligned with preplanned reductions, the shortages served as additional justification for scaling back the tank program and could have been disastrous if the Army had been more committed to meeting Roosevelt's stated tank objectives.

Infrastructure and Tooling Requirements

The automotive industry demonstrated significant industrial capability at the onset of the defense period, but it lacked the specialized facilities and tooling needed to design, build, test, and repair tanks.[139] The lack of preexisting production capacity for tanks was directly linked to the Army's limited demand during the interwar period. Furthermore, private industry was completely excluded from tank production and design processes. Only two educational orders were approved for tank production during the prewar period, and neither of these contracts improved manufacturing readiness in a meaningful way.[140] The outcome was that the automotive industry was wholly unprepared to modify existing facilities to produce tanks or tank components. Recognizing this, Knudsen advocated for the construction of brand-new facilities, the largest of which were the Detroit Tank Arsenal and the

138 Thomson and Mayo, *The Ordnance Department Procurement and Supply,* p. 255.

139 Stout, *"Tanks Are Mighty Fine Things,"* p. 18.

140 Thomson and Mayo, *The Ordnance Department Procurement and Supply,* pp. 224–225.

Fisher Body Plant. The impact of these GOCO plants on tank production output cannot be overstated. Together, they accounted for over 40 percent of all tank production output during the war and produced 35,371 tanks.[141] The rapid construction of these facilities unquestionably contributed to the significant increase in tank production during 1942 and 1943.

The need for new machine tools was closely tied to the infrastructure issue. Machine tools were a major bottleneck in tank production during the war because the Ordnance Department received lower priority than the Navy and the Air Corps.[142] This issue was compounded by the specialized tools that were often required to produce tanks. Chrysler alone required 1,000 machine tools and 8,500 specialized fixtures at the Detroit Tank Arsenal to begin production of the M3 medium tank.[143] The machine tool bottleneck was effectively addressed through government-subsidized production by the DPC. Furthermore, machine tool panels were established within each of the Ordnance Department's districts to identify underutilized tools across industry.[144]

Design Changes in Tank Manufacturing

Another major obstacle was the evolution of tank designs, which forced tank manufacturers to constantly adjust production lines and obtain new equipment to accommodate changes. The design changes were often driven by combat experience, engineering enhancements, and shifts in tactical concepts to ensure the optimal product for soldiers on the battlefield. The Ordnance Department's desire to produce the best possible weapon made these design changes largely nonnegotiable, regardless of the disruptions they caused to manufacturers. Additionally, the complex nature of tank designs made production changes inevitable. Early orders for the M2A4 tank required 2,800 different parts, 14,000 individual pieces, and 2,000 separate blueprints.[145] A design flaw in even a single critical piece could cause major disruptions across the entire production line. Automakers endeavored to avoid delays despite design alterations; however, this proved to be extremely challenging due to the numerous tank variants developed. They leveraged their industrial expertise to maintain production schedules as best as possible. Their yearly changes in passenger car models gave them valuable experience with implementing design modifications rapidly and frequently.[146]

141 Thomson and Mayo, *The Ordnance Department Procurement and Supply*, p. 242. In particular, the Detroit Tank Arsenal transitioned into a final assembly hub for tank components manufactured at other locations, but it remained critical to the war effort as one of the few facilities large enough to accommodate full-scale tank assembly.

142 Ibid., pp. 38–39, 225, 231, 238, 246–247.

143 Hyde, *Arsenal of Democracy*, p. 122; and Thomson and Mayo, *The Ordnance Department Procurement and Supply*, p. 242.

144 Thomson and Mayo, *The Ordnance Department Procurement and Supply*, p. 471.

145 Ibid., p. 225.

146 Thornton, *Tanks and Industry*, p. 16.

Additionally, automakers worked closely with the Ordnance Department's tank committees to clarify designs and manage friction resulting from frequent changes to specifications.[147] The inherent adaptability of the automakers was undoubtedly a key factor that prevented substantial production delays. As one Army officer put it, "Only a man who has taken part in the design, tooling and production of the new model of automobile or other complicated piece of machinery can adequately understand the unforeseen and unforeseeable difficulties of such a task."[148]

147 Ibid., p. 41; and Thomson and Mayo, *The Ordnance Department Procurement and Supply*, p. 36.

148 Bos and Talbot, *Enough and On Time*, p. 34.

CHAPTER 5

Historical Insights for Modern Mobilization Strategy

The modern DIB is once again under scrutiny amid rising concerns about great power competition and the increased likelihood of large-scale conflict. The U.S. DIB faces challenges similar to those encountered by the automotive industry from 1940 to 1945—now exacerbated by an eroded industrial sector and the increased sophistication of modern weapon systems.[149] Contemporary defense strategists can derive valuable insights from both the tank production case study and from the broader challenges encountered in converting America's economy into the arsenal of democracy.

Building Defense Production Capacity in Peacetime

The United States must build its production capacity in peacetime to prepare the DIB for increased wartime demand. Defense readiness is not necessarily about producing weapons today; rather, it is about positioning the DIB to scale rapidly for the future. The interwar IMP failed to address the possibility of rapid expansion in the face of a crisis short of war. Future mobilization plans can avoid the pitfalls of the IMP by planning mobilization across the entire conflict continuum.

Furthermore, the tank case study highlights the importance of maintaining strong manufacturing and industrial capacities that can be efficiently transitioned to defense production. Tank production did not reach its full potential until the construction of GOCO plants was completed and machine tool shortages were resolved. Countless production hours were lost while the United States procured this infrastructure, which underscores the need to develop capacity well ahead of conflict.

149 Harman et al., *Commission on the National Defense Strategy* (Washington, D.C.: RAND, 2024), pp. 51–57.

The DIB's current production capacity is not sufficient to meet the projected requirements of a prolonged future conflict, just as the automakers were not positioned to meet projected defense requirements during the early mobilization period. The DoD can mitigate these risks by expanding capacity within its existing defense contractor base and by incentivizing convertibility in key civilian industrial sectors. The latter point could be crucial to building peacetime capacity in a budget-constrained environment and will be discussed in later sections of this report.

Adapt Defense Production for Rapid Technological Change

Equipment standardization and design stability matter, but they are difficult to achieve for complex and emerging capabilities. This was a substantial challenge encountered by the automotive industry that was primarily resolved through its extensive industrial expertise and adaptability. The U.S. military must strive to provide clearer production requirements to the defense industry with minimal changes over time; however, this will be difficult as technologies such as drones, long-range precision strike, and AI continue to evolve at a rapid pace. To account for this, the DoD can increase experimentation with emerging capabilities and new doctrinal concepts in live and constructive training exercises to inform future design changes. Such experimentation could have addressed some of the Army's difficulties with improving tank designs and doctrine before World War II.

Additionally, the DoD can enhance technological adaptability in the joint force by using modular components that enable easy upgrades and the customization of weapon platforms for different applications.[150] Modularity accelerates production scaling by enabling concurrent manufacturing across suppliers and by applying standard components to multiple platforms. The DoD already uses the modular open system approach (MOSA) within the Defense Standardization Program to accomplish this, but the U.S. Government Accountability Office (GAO) recently identified a number of issues with its implementation. Most notably, the GAO found that most military acquisition programs do not effectively integrate MOSA elements into procurement processes and that the DoD does not coordinate across multiple MOSA portfolios to fully benefit from using standard components.[151] The GAO recommended that each Service "establish a formal process for coordinating MOSAs across programs to enable portfolio-wide benefits."[152] Furthermore, future industrial conversion programs can integrate MOSA planning to increase scalability in the production of high-demand platforms.

150 Richard Danzig, *Driving in the Dark: Ten Propositions about Prediction and National Security* (Washington D.C.: Center for New American Security, 2011), pp. 23–25.

151 U.S. Government Accountability Office, *Weapon Systems Acquisition: DOD Needs Better Planning to Attain Benefits of Modular Open Systems*, Report to Congressional Committees GAO-25-106931 (Washington, D.C.: U.S. Government Accountability Office, 2025), https://www.gao.gov/products/gao-25-106931.

152 U.S. Government Accountability Office, *Weapon Systems Acquisition*.

Finally, adaptation is hindered by a faulty DoD acquisition system that is too complex and rigid to quickly create meaningful change.[153] The process must be reformed to enable the rapid development and acquisition of critical capabilities in the face of unexpected demand. Furthermore, the defense industry must be able to rapidly adapt if it is to meet changing battlefield requirements.

Balance Capability and Scalability

A future large-scale conflict will demand tradeoffs between exquisite weapon systems and the ability to produce high volumes of these systems. Recent defense policy and military strategy literature has extensively examined this issue, with many advocating for the creation of simpler, more affordable systems rather than fewer expensive platforms that require long production times. This approach could alleviate the strain on DIB production capacity by addressing two critical factors in mass mobilization: time and money. Furthermore, transitioning to simpler weapon designs could lower the barrier to entry for manufacturers that lack the organic expertise or resources to produce more advanced systems.

Although there is merit to this argument, using masses of attritable systems is not appropriate for every mission set or operational environment, and the United States could lose a significant military advantage if it just casts aside most of its high-end systems. Transitioning to simpler weapon designs could also have second-order effects on the way the U.S. military operates and on the risks posed to the service members who use these systems on the battlefield. A healthy mixture of high- and low-end capabilities could help alleviate these risks while ensuring the United States has the depth to sustain a prolonged war.[154] High-end capabilities could be reserved for the most critical missions—those where precision, maneuverability, and speed are required—and more affordable, mass-produced systems could be used for less-demanding tasks that require the massing of capabilities.[155] To accomplish this, each military Service should identify the optimal combination of advanced and basic capabilities tailored to its specific mission needs.

Strengthen National Stockpiles and Supply Chain Resilience

Material shortages affected virtually all industries during World War II and were a major hindrance to meeting tank production quotas in 1942. After Pearl Harbor, the U.S. steel industry was cut off from its major foreign suppliers of ferroalloys, which were critical

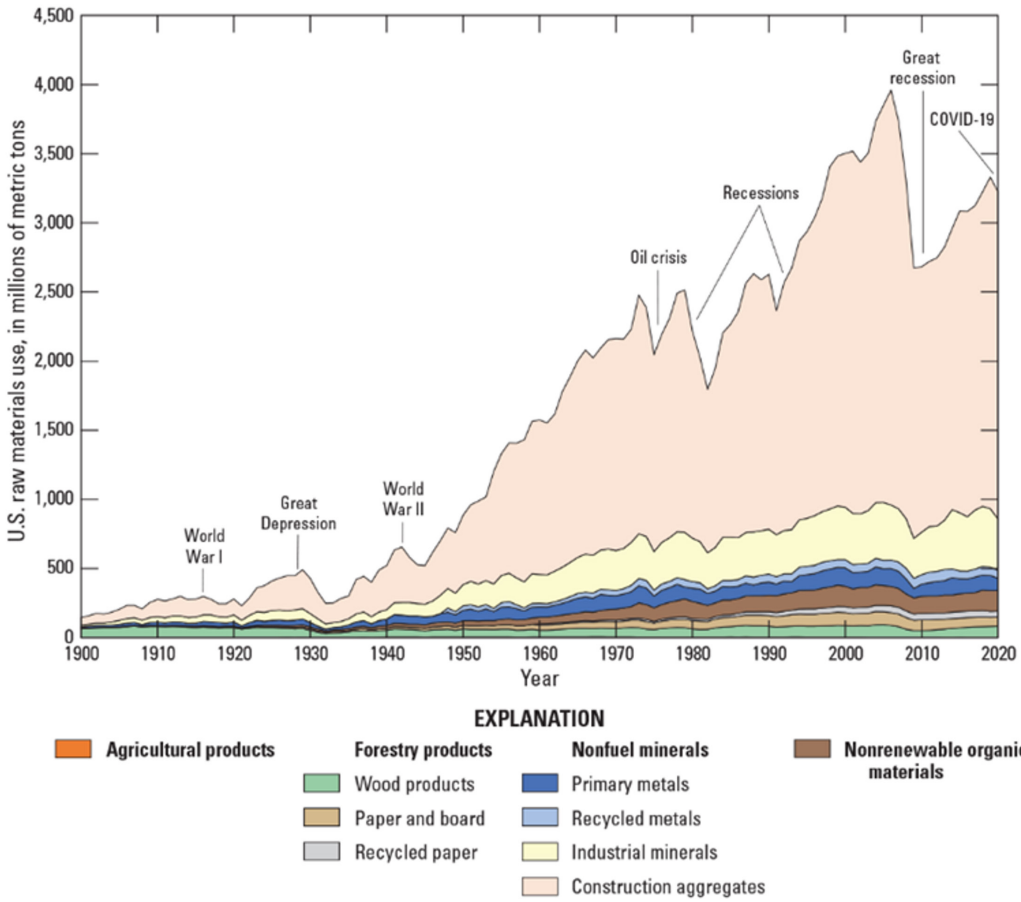
153 David Barno and Nora Bensahel, *Adaptation under Fire: How Militaries Change during Wartime*, (Oxford: Oxford University Press, 2020), pp. 256–257.

154 Bryan Clark, Dan Patt, and Nadia Schadlow, *Ending Self-Imposed Scarcity: Exploiting America's Commercial Strengths to Mobilize Weapons Production* (Washington, D.C.: Hudson Institute, March 2025), p. 17.

155 Clark et al., *Ending Self-Imposed Scarcity*, pp. 15–17.

in supplying armor plating and other components for tank production.[156] Such shortages would likely have even greater consequences in today's globalized supply chains. Moreover, the United States has significantly increased its consumption of raw materials to support population growth and maintain its high standard of living (see Figure 8). This increased consumption, combined with disruptions in critical mineral imports, could exacerbate raw material shortages in the event of a large-scale conflict that leads to increased demand.

FIGURE 8: U.S. ANNUAL USE OF RAW MATERIALS, 1900–2020



Source: U.S. Geological Survey, National Minerals Information Center, https://pubs.usgs.gov/publication/dr1164/full#dr1164-r4

It is unlikely that America's current stockpiles of critical minerals would provide any relief from such shortages. A fiscal year (FY) 2023 assessment of the National Defense Stockpile found a $14.83 billion shortfall in 88 stockpiled materials that are critical for civilian and military requirements.[157] Moreover, after adjusting for inflation, the current funding for

156 McLaughlin Green and Roots, *The Ordnance Department: Planning Munitions for War*, p. 480.

157 Cameron Keys, *Emergency Access to Strategic and Critical Materials: The National Defense Stockpile* (Washington, DC: Congressional Research Service, 2023), p. 9.

stockpiled materials is only 80 percent of what it was in 1940 and merely 22 percent of the 1941 level.[158] Additional appropriations could expand the National Defense Stockpile to increase material readiness, avoid critical shortages, and reduce dependency on foreign suppliers in a conflict situation. The DoD can also incentivize DIB reshoring initiatives to mitigate the risk of adversaries compromising global supply chains, although this effort would require broader reshoring of industries that provide raw materials such as steel, aluminum, and rare earths. Such measures would entail higher upfront costs for the government but are critical for long-term defense preparedness.

Balance Government Regulation and Free Enterprise in Times of National Emergency

Political leaders in Washington must be prepared to carefully balance government regulation and free enterprise in times of crisis to ensure the nation can sustain a prolonged, high-intensity conflict. The friction between government regulation and free enterprise was deeply ingrained in every facet of the World War II mobilization effort. Government officials and industrialists strived to limit the impact of mobilization on private businesses for as long as possible. The U.S. government eventually increased regulation of private enterprise after Pearl Harbor, but the uncoordinated nature of peacetime conversion left a negative mark on the U.S. mobilization effort. Government leaders will face similar challenges in future crises and must carefully balance defense requirements with their duty to protect the free enterprise system that defines America. A future conflict with Russia or China may require the United States to prioritize material conservation policies in a crisis short of war so it can prevail when conflict finally occurs.

Opponents of this position may claim that such thinking erodes the very democratic and capitalist principles that America sought to protect during World War II, but the United States has a storied history of maintaining these values through times of hardship. Roosevelt himself was cognizant of his duty to maintain the country's democratic principles in wartime, which he summarized in a 1940 fireside chat:

> We must make sure, in all that we do, that there be no breakdown or cancellation of any of the great social gains which we have made in these past years. We have carried on an offensive on a broad front against social and economic inequalities and abuses which had made our society weak. That offensive should not be broken down by the pincers movement of those who would use the present needs of physical military defense to destroy it.[159]

Roosevelt and his administration consistently demonstrated their commitment to this way of thinking by moderating regulatory requirements during early mobilization and by

158 Keys, *Emergency Access to Strategic and Critical Materials*, pp. 9–10. Appropriations for FY 2023 were $218.5 million. Total appropriations were $272,258,957 in 1940 and $969,527,778 in 1941 (in constant FY2024 dollars).

159 McCauley, *Conversion of the Consumer Durable Goods Industry*, p. 51.

carefully considering the impact the defense program would have on private enterprise. The political discourse between New Dealers and conservatives in World War II also ensured that government regulatory authority was consistently monitored and reviewed. Finally, government controls were lifted even before victory was assured, which highlights the seriousness with which government officials took their stewardship of the American economy.

CHAPTER 6

A 21st-Century Conversion Model

> Leveraging Freedom's Forge 2.0 for Advanced Manufacturing, new dual-use factories can produce commercial goods during peacetime and pivot to weapons manufacturing during wartime, which would significantly reduce costs for both taxpayers and consumers.... The new manufacturing network built for scalability will ensure future crises are met with ready-to-scale defense production, unlocking the full potential of U.S. and allied industrial bases.
>
> —David Berger et al., *Strategic Edge*, January 2025[160]

Industrial Conversion's Modern Potential

Although this case study highlights the need for the United States to build its peacetime industrial base, it is less clear whether the industrial conversion model used during World War II is appropriate in today's context. This report illustrates the immense difficulty of conversion at that time. World War II efforts faced numerous challenges that limited the government's ability to convert existing industrial capacity, which forced it to fund costly, time-consuming infrastructure projects. Although these projects resulted in increased production capacity, they were hardly the conversion practices that interwar mobilization planners had in mind when crafting the IMP.

Equivalent efforts today would be even more problematic, given the growing complexity of U.S. weapon systems, the technical expertise required in defense manufacturing, and the globalized supply chains that support defense contractors. It may be impractical or even impossible to produce many modern, exquisite war materials via converted production lines alone. Additionally, unlike in the 1940s, the modern DIB is dominated by large contractors

160 David Berger et al., *Strategic Edge: A Blueprint for Breakthroughs in Defense Innovation* (New York: Mike Bloomberg, 2025), p. 27.

already dedicated to war production. On the surface, it seems most plausible to expand the capabilities of these defense contractors, who already have experience and expertise in defense-related work. However, several limitations with this approach (and within the broader DIB) highlight the need for closer consideration of the industrial conversion model as a viable alternative to augmenting current defense contractor capacity.

First, expanding the peacetime capacity of existing prime contractors would come with a hefty price tag, likely at the expense of the U.S. taxpayer. Before World War II, neither the automotive nor the machine tool industries were willing to invest in excess production capacity due to the unpredictable nature of defense work and the potential that manufacturing infrastructure would be unusable after the war. There is a similar reluctance today among major defense contractors to increase peacetime production capacity, albeit for different reasons. Many policymakers argue that defense companies are prioritizing profits and shareholder returns over capital investment and that a lack of competition in the DIB provides little motivation for current defense primes to change the way they do business.[161] The DoD could promote venture capital investment in the DIB to expand the pool of defense contractors, thereby creating new production capacity and promoting competition. However, this strategy would require unprecedented and ahistorical private investment to establish enough capacity to sustain a protracted conflict. It would also require increased demand signals from the DoD in peacetime to ensure the long-term survival of these new businesses. Neither of these limiting factors is guaranteed within a budget-constrained environment.

Given these considerations, the U.S. government would likely need to bear most of the costs to create excess production capacity in peacetime. Not only would this require significant investment of taxpayer dollars, but much of the peacetime capacity would also go unused until a period of crisis or war. The combination of high price tags and long-term idleness of excess infrastructure may not be politically viable for Congress or the White House. Industrial conversion presents a viable alternative by eliminating the need to build infrastructure from scratch, thereby reducing the financial burden on both the government and defense contractors during prolonged periods of peace. Industrial conversion practices also remove political barriers by reducing the need for excess capacity while providing a rapidly scalable solution to the DIB's capacity shortfalls.

Second, there is significant risk in consolidating defense production needs into just a handful of large companies. It is widely argued that the U.S. homeland will no longer act as a sanctuary in a war against a peer adversary. Russia and China possess the capabilities to target the critical infrastructure or operational processes of large prime contractors through both kinetic and nonkinetic means. Given the centralization of defense work in the modern DIB, such disruptions could have widespread consequences. Expanding production to a

161 Luke Nicastro, *The U.S. Defense Industrial Base: Background and Issues for Congress* (Washington, DC: Congressional Research Service, 2024), pp. 33–34; and Berger et al., *Strategic Edge*, p. 18. In the defense industry, capital investment refers to expenditures that support the long-term growth of the DIB and includes projects that improve production capacity through the acquisition of manufacturing facilities, advanced technologies, and equipment.

broader base of commercial companies could mitigate these risks by compartmentalizing total U.S. production capabilities.

Third, industrial conversion could promote competition within the DIB and leverage underutilized production capacity in small businesses. The DoD's National Defense Industrial Strategy (NDIS) cites the need to reduce barriers to entry for small and medium-sized businesses in defense work.[162] Modernized conversion planning and educational contracts could help remove such barriers and identify which small businesses were most suited for future government investments. Additionally, leveraging small businesses in wartime would unlock otherwise underutilized production capacity in the U.S. economy. Small businesses made significant contributions to the automotive industry's production success during World War II by producing components and parts for larger firms.[163] As of 2025, there were approximately 36.2 million small businesses in the United States; they employed 45.9 percent of U.S. workers.[164] Of these businesses, 632,885 are directly involved in manufacturing.[165] The DoD could leverage these extensive resources by instituting industrial conversion programs that would grow small businesses into larger prime contractors or enable them to become subcontractors for existing primes.

Fourth, industrial conversion programs could increase innovation across the defense industry by providing defense prime contractors access to expertise in emerging technologies. The NDIS states, "DoD currently underutilizes innovations and advancements originally developed for non-military purposes that could be quickly and cost-effectively adapted for military use."[166] In World War II, the aircraft industry harnessed mass production innovations from automakers to increase its production of military aircraft. Modern industrial conversion programs can adopt a similar strategy by fostering collaboration between commercial firms and major defense contractors to integrate emerging technologies in space, AI, quantum computing, additive manufacturing, and biotechnology into existing defense production.

Finally, workforce shortages will plague any attempts to create additional production capacity in the DIB. Major defense contractors are already struggling to grow their workforce in the face of stiff competition from other big tech companies, employee turnover, and

162 DoD, *National Defense Industrial Strategy* (Washington, D.C.: DoD, 2023).

163 Automobile Manufacturers Association, *Freedom's Arsenal*, p. 154.

164 U.S. Small Business Administration Office of Advocacy, *2025 Small Business Profile,* 2025, https://advocacy.sba.gov/wp-content/uploads/2025/06/United_States_2025-State-Profile.pdf.

165 U.S. Small Business Administration Office of Advocacy, *2025 Small Business Profile*.

166 DoD, *National Defense Industrial Strategy*, p. 10.

an aging U.S. labor pool.[167] An increase in production capacity would only exacerbate this challenge in peacetime. During wartime, the U.S. may face a severe labor shortage if war materiel needs skyrocket and there are not enough skilled workers in specialized defense fields to meet the demand. A modern industrial conversion program could alleviate potential labor shortages by training workforces in both commercial and defense production.

Although some may argue that modern industrial conversion is impractical, policymakers should carefully evaluate the feasibility of utilizing nondefense companies to augment the DIB. A modern-day U.S. industrial conversion program could increase flexibility and resiliency in the DIB, provide additional production capacity in wartime, and promote rapid innovation in response to battlefield needs—all while reducing costs for the DoD.

Modern Approach: The Civil Reserve Manufacturing Network

As mentioned previously, the current U.S. DIB is well established and has an extensive track record. For a contemporary conversion program to be successful, the DoD would need to integrate converted production capacity with existing capabilities into a more unified mobilization plan than the haphazard conversion model employed during World War II. The House Appropriations Committee's defense panel recently proposed allocating $131 million to establish a Civil Reserve Manufacturing Network that would include a group of commercial companies capable of quickly transitioning to defense production when called upon.[168]

This proposal was recommended in a study commissioned by Michael Bloomberg and is described as a mechanism for increasing surge capacity in times of war at reduced cost to the U.S. taxpayer. The report calls for a program that would "allow the U.S. to quickly surge production during wartime by leveraging a commercial network of certified factories and provide government incentives to participating companies."[169] This proposal could provide the DoD with a comprehensive, deliberate industrial conversion program that would be capable of remedying the challenges faced by mobilization planners during World War II. The next sections outline broad considerations for establishing an industrial conversion program under the manufacturing reserve model.

167 Eric Chewning, Matt Schrimper, Andy Voelker, and Brooke Weddle, "As Aerospace and Defense Players Accelerate Their Mission to Transition from Hardware to Software, We See Four Talent Imperatives," McKinsey and Company, July 2022, https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/debugging-the-software-talent-gap-in-aerospace-and-defense; Hope King and Colin Demarest, "Defense Industry Rushing to Hire Workers as Military Spending Spikes," Axios, June 2024, https://www.axios.com/2024/06/21/defense-sector-labor-shortage-militatry-spending; and Derrick Ryskamp, "Aerospace and Defense Industry's Demand for Talent Outpaces Supply," Acara Solutions, January 2025, https://acarasolutions.com/blog/recruiting-trends/aerospace-and-defense-industrys-demand-for-talent-outpaces-supply.

168 Courtney Albon, "House Proposes Manufacturing Network to Boost Wartime Arms Production," *Defense News*, June 2025, https://www.defensenews.com/pentagon/2025/06/12/house-proposes-manufacturing-network-to-boost-wartime-arms-production.

169 Berger et al., *Strategic Edge*, p. 27.

Strategies to Align Requirements with Convertible Industry

The DoD must identify production gaps in the current DIB and align these demands with available capabilities in the broader private sector. This alignment can occur in a number of ways, depending on the complexity of the military equipment and the existing production capabilities of participants in a manufacturing reserve. This report outlines three broad alignment strategies that the DoD could employ to establish a base of participants beyond the conventional DIB.

First, the DoD could identify simple-to-produce, yet high-demand, military equipment for mass production by companies serving in prime contractor roles. These companies must have established manufacturing resources and expertise that enable them to rapidly convert to the production of major end items. This approach is similar to the automotive industry's production of wheeled military vehicles during World War II, when the automakers utilized their existing facilities and industrial know-how to produce trucks and jeeps. To implement this strategy, the DoD must determine which military requirements would be needed in large quantities for a major conflict and then identify commercial vendors that could produce these items independently from existing prime contractors. Some possible examples include wheeled vehicles, engineering equipment, small caliber munitions, maintenance and medical supplies, commercial drones, and small armaments. This equipment is simpler to produce than more advanced munitions or combat platforms and would be required in large quantities for future conventional conflicts.

Second, the DoD could resolve bottlenecks in the production of complex military equipment (e.g., fighter aircraft, naval vessels, and advanced missile systems) by employing reserve manufacturing companies as subcontractors to augment prime defense contractor capacity. This strategy would use converted companies to supply essential parts or services to defense primes, thereby reducing delays and increasing the total output of complex military systems. This approach is analogous to the automotive industry's production of aircraft engines and parts for the aviation industry to meet Roosevelt's production goals for military aircraft.

The military Services are already using this method to address modern production challenges in their supply chains. For example, the Navy recently identified supply chain shortages in both rocket motors and electronic parts that are critical to the production of air defense and anti-submarine missiles.[170] To resolve these backlogs, the Navy engaged new vendors that either rapidly acquired the necessary production skills or redesigned the components to enable faster manufacturing. Overall, this alignment strategy augments the DIB with existing capacity in the private sector, thus avoiding the need for costly investments in additional capacity for defense primes. Subcontracting could extend beyond the

170 Megan Eckstein, "Supplier Bottlenecks Threaten U.S. Navy Effort to Grow Arms Stockpiles," *Defense News*, February 2024, https://www.defensenews.com/naval/2024/02/06/supplier-bottlenecks-threaten-us-navy-effort-to-grow-arms-stockpiles.

production lines to remedy software, engineering, and other technical problems that would normally lead to delays.

Third, the DoD could collaborate with leading innovators in emerging commercial technologies to improve legacy equipment and develop new military capabilities to address evolving battlefield requirements. This approach is similar to the automotive industry's innovations in tank engines, armor plating, and hull designs, which were in response to deficiencies identified in combat. Today, the DoD could leverage companies on the cutting edge of AI, renewable energy, space, and other high-tech sectors to address challenges beyond the scope of current defense contractors. This capability already exists within the DoD's Defense Innovation Unit (DIU), which is responsible for accelerating the adoption of commercial technology through other transaction (OT) contracts. DIU's scope could be expanded to include collaborating with reserve manufacturing companies to address technological challenges identified in the initial phases of a large-scale conflict.

The alignment approaches described above are broad and must be accompanied by a deliberate effort to identify sectors of the U.S. economy that are well suited for conversion. This effort would require advanced knowledge of both military requirements and the capabilities of existing private sector manufacturing. Although such detailed analysis is beyond the scope of this report, the following sectors should be considered for inclusion in a modern industrial conversion program:

- **automotive industry:** parts, vehicles, maintenance equipment, and engines.
- **consumer electronics industry:** sensors, communications equipment, and small electronic components.
- **pharmaceutical and healthcare industry:** medical supplies and biotechnology.
- **heavy manufacturing industries:** large armaments, shipbuilding, and munitions.
- **additive manufacturing:** mission-critical parts with short lead times.
- **construction industries:** rapid infrastructure development and construction projects.
- **software development and cybersecurity firms:** command and control systems, logistics networks, AI integration, and cyber warfare.
- **textiles and other consumer goods:** uniforms, body armor, field tents, and other small kits.
- **industrial chemical suppliers:** Explosives and chemical, biological, radiological, and nuclear decontamination capabilities.
- **food industry:** rations and ready-to-eat meals.

Leverage Outsourcing Partnerships: Contract Manufacturers and ODMs

In addition to aligning commercial capabilities through prime or subcontractor roles, the DoD could expand production capacity by tapping into contract manufacturing and original design manufacturer (ODM) networks, both of which are sectors of the U.S. economy well versed in high-volume, scalable production.[171] Contract manufacturers are companies hired to produce goods on behalf of another company under a contractual agreement, usually based on the originating firm's design and specifications. In this approach, defense companies would lead munitions research and design, using their in-house technical expertise, while contract manufacturers would refine the design and manufacturing processes for mass production.[172]

Similarly, the DoD could use ODMs to design and mass-produce less complex military equipment. ODMs are similar to contract manufacturers, but they handle both the design and production of the product under contract. Although these firms are unlikely to have the expertise necessary to design advanced weapon systems, ODMs are well suited to manufacturing a wide array of military equipment or individual components that demand less technical proficiency.

Similar outsourcing methods were used by the War Department during World War II to mass produce tanks. Chrysler contributed hundreds of redesigns that were implemented during the Army's development of the M3 tank, which made them faster, cheaper, and easier to manufacture.[173] The automaker's contributions were not limited to the M3. The firm's engineers also developed a tank engine for the M4 Sherman, which was fashioned from five existing Chrysler six-cylinder motors, thereby greatly increasing the production speed of the new tank.[174] Chrysler's engineering team also led the entire design and cost estimation for the renowned Detroit Tank Arsenal, going so far as to construct a wooden replica of the M2A1 to confirm that all components aligned correctly and could be assembled efficiently in the new facility.[175]

Modern-day contract manufacturers and ODMs could take on a similar role by using their specialized expertise to increase cost efficiency and scalability in weapon designs and production processes. The Hudson Institute has identified several case studies in which such manufacturing processes are already in use to produce solid rocket motors and small unmanned aircraft system components for the Army's air-launched effects program.[176] Expanding this method would give the DoD access to robust production capacity within the

171 Clark et al., *Ending Self-Imposed Scarcity*, pp. 32–38.

172 Ibid., p. 36.

173 Stout, "*Tanks Are Mighty Fine Things*," pp. 21–22.

174 Ibid., p. 35.

175 Ibid., p. 16.

176 Clark et al., *Ending Self-Imposed Scarcity*, pp. 33, 35.

U.S. economy, since the contract manufacturing sector generates a combined annual revenue of $85 billion and has substantial experience operating at large scales.[177]

The success of this approach requires open and reciprocal collaboration between weapons designers and manufacturers. Chrysler's success in tank production was contingent on the Army's willingness to accept numerous design changes. Similarly, today's major defense contractors must be equally open to an iterative redesign process if they utilize contract manufacturers. Additionally, these outsourcing models would require the DoD and defense primes to use widely available commercial components in weapon designs, given that contract manufacturers achieve scale and cost-effectiveness primarily through such parts.[178] Such commercial components may not conform to DoD technical standards and design specifications, which may require tradeoffs between capability and scalability in future weapon designs.

As noted earlier in this report, the DoD should weigh the risks and second-order effects of these tradeoffs, seeking an appropriate balance between capabilities that sustain U.S. military advantages and those that support mass production in a protracted conflict. Both options must be assessed for inclusion in the Civil Reserve Manufacturing Network.

Mechanisms for Conversion Planning in a Commercial Reserve Program

Integrate corporate planning within broader mobilization strategies. Merely identifying companies for conversion is not enough to create an effective Civil Reserve Manufacturing Network. The U.S. military would need to craft individualized conversion plans in collaboration with each company to enable rapid mobilization during a national emergency. Effective planning would identify existing infrastructure capabilities, lead time requirements, workforce needs, and resource shortfalls in the conversion process. In turn, these factors should inform contracting requirements and obligations for participating companies. Mobilization planners must also integrate conversion plans within broader economic constraints to avoid nationwide resource shortages and supply chain bottlenecks like those experienced during World War II. Finally, conversion plans should be validated through tabletop exercises and feasibility assessments that incorporate input from private industry, the military Services, and the Office of the Assistant Secretary of Defense for Industrial Base Policy. The following is a partial list of questions to guide planning efforts:

- Can the company produce military equipment using existing production lines rather than newly constructed facilities and capabilities?

177 Ibid., p. 32.

178 Ibid., p. 32.

- Are there materials, processes, or parts that the company currently lacks that are essential in the production of the military item? How quickly can these requirements be resourced?
- Will the company need to curtail its commercial business to conduct defense work? If so, by how much?
- What are the broader economic impacts if commercial curtailment is implemented?
- What are the major differences between commercial and military standards for the item being produced? Which standards will be used for converted production?
- Can the military include more commercial parts in production to make the conversion process easier?
- Are there critical raw materials or components that could become scarce if there is a sudden increase in demand?
- What training is required for the company's workforce to transition to defense work?
- Can the company's workforce accommodate a rapid increase in production requirements, or will the company need to hire and train additional workers? If so, how long will this take?
- Will the conversion process lead to workforce layoffs? If so, how can this be mitigated?
- How much of the company's supply chain is overseas? If so, where overseas?
- Could the company's supply chain be threatened by adversary intervention?
- Can the company quickly adapt to unexpected design changes?
- Can the company collaborate with other industry leaders to resolve technical challenges?
- Are there intellectual property hurdles to overcome in the conversion process?

Establish financial incentives that motivate participation in the conversion program. Attracting a broad base of companies and preserving long-term conversion capacity would likely require financial incentives. Although these incentives would incur some costs to the government, they would likely be more economical than creating entirely new infrastructure and capacity from scratch. The U.S. government could leverage tax credits, subsidies, low-interest loans, or grants to encourage corporate participation in the program. Modest, long-term funding would also ensure companies met conversion requirements and promote dual-use capital investment. Such incentives would offset the burdens of government audits, certification, and oversight that might otherwise discourage participation in a manufacturing reserve program.

Establish a certification process, routine audits, and oversight mechanisms that ensure companies can meet their conversion commitments in wartime. A formal certification procedure would ensure that companies within the reserve were prepared for conversion and could meet their contractual obligations as identified in the conversion planning process. Oversight mechanisms, such as audits, could also be used frequently to ensure the long-term readiness of private enterprises and to validate that they were meeting their peacetime readiness obligations. Furthermore, conversion contracts would need to be regularly reevaluated to ensure they met current military requirements.

Leverage OT Agreements as Modern Educational Orders. The DoD could revive the educational order concept on a broader scale by using OT agreements that support conversion efforts. OT agreements are legally binding DoD contracts that bypass procurement-related regulations to enable research and prototyping projects with the commercial sector.[179] In 2024, the DoD submitted several proposed changes to Section 4022 of Title 10 U.S. Code that expand the use of OT agreements to projects in the following circumstances:[180]

- a proof of concept, model, or process, including a business process
- reverse engineering to address obsolescence
- a pilot or novel application of commercial technologies for defense purposes
- agile development activity
- the creation, design, development, demonstration of operational utility; or any combination of the foregoing

As of June 20, 2025, this terminology has been adopted in the U.S. Code.[181] The expanded scope of a prototype project could allow the DoD to use OT agreements to assess the feasibility of converting companies to war production. OT agreements could serve as proof of concept that assesses a manufacturer's potential for future defense work through low-volume procurement projects, such as repair parts for Ukrainian equipment or subcontracting for larger defense contractors.[182]

179 David Carpenter and Alexandria Neenan, *Defense Primer: Other Transactions (OTs)* (Washington, DC: Congressional Research Service, 2024), https://www.congress.gov/crs-product/IF12856.

180 "Transactions Other than Contracts, Grants, or Cooperative Agreements for Prototype Projects: A Proposed Rule by the Department of Defense," Federal Register, https://www.federalregister.gov/documents/2024/09/04/2024-19457/transactions-other-than-contracts-grants-or-cooperative-agreements-for-prototype-projects.

181 Authority of the Department of Defense to Carry Out Certain Prototype Projects, 10 USC § 4022 (2025), https://uscode.house.gov/view.xhtml?req=(title:10%20section:4022%20edition:prelim)#effectivedate-amendment-note.

182 "Building a U.S. Manufacturing Ready Reserve," Sustainment, https://www.sustainment.com/manufacturing-ready-reserve.

CHAPTER 7

Initial Steps Toward a Manufacturing Reserve

U.S. industrial capacity played a crucial role in sustaining the Allies' victory in World War II, despite challenges between free enterprise and government authorities, the absence of prewar infrastructure, and the complexities of frequent design changes in mass production. The automotive industry was particularly important given its central role in the government's IMP. The automotive industry and government authorities overcame these obstacles through a combination of government regulatory practices and industrial expertise.

The great arsenal of democracy offers enduring lessons for modern defense strategists. Preparing for future large-scale conflict demands more than reactive conversion measures. It requires deliberate, peacetime investments in production capacity, improved supply chain resilience, and clear policy decisions about the government's role in defense preparedness.

A modern-day conversion program offers U.S. policymakers a cost-effective option to expand defense production capacity in peacetime without incurring the expense of building spare infrastructure from the ground up. At the time of writing, the proposed Civil Reserve Manufacturing Network provides the clearest path to establishing such a program. The DoD is expected to develop a method of assessing and certifying companies following the legislation's enactment.[183] To accomplish this, leaders in the Pentagon must build a comprehensive approach that ensures the long-term viability of the network and its complete integration with existing DIB capabilities. The following recommendations, gleaned from World War II industrial mobilization, can assist in executing this crucial first step:

183 "House Proposes Manufacturing Network to Enhance Wartime Arms Production Capabilities," Defcros News, June 2025, https://news.defcros.com/house-proposes-manufacturing-network-to.

- Establish a robust agency charged with implementing the program (or similar industrial conversion program) and arm it with the authority needed to nest it within a broader mobilization framework. Ideally, such an agency would report directly to the secretary of defense.
- Congress must create clear authorities, codified in law, that empower the manufacturing reserve agency to activate companies in times of crisis or war. Activation requirements and triggers must also be clearly delineated for a crisis short of war.
- Ensure the military Services provide clear production requirements to the agency charged with establishing the program. Companies must be chosen based on specific and stable (to the extent feasible) military requirements.
- Cast a wide net when assessing companies for inclusion in the program. The War Department surveyed approximately 25,000 companies during its interwar mobilization planning. A comparable survey can be conducted today to fully capitalize on latent commercial production capacity within the U.S. economy.
- Leverage executive-level talent from private industry to assess companies. Although the dollar-a-year men were controversial for their close links to big business, they brought with them years of industry expertise. Knudsen was eventually commissioned as a lieutenant general in the U.S. Army, where he continued to influence production policy throughout the war. The U.S. Army is taking a similar approach today with its launch of Detachment 201 and the commissioning of four top tech executives into the Army Reserves.[184] A similar effort could be taken at the DoD level to support the implementation of an industrial conversion program.
- Ensure that existing weapon design requirements do not restrict the participation of businesses in the manufacturing reserve. Design flexibility and scalability are paramount in leveraging the full capacity of commercial companies.
- Assess companies for their ability to integrate with the current DIB, either as subcontractors or contract manufacturers.
- Understand that cost sharing is still inevitable. Although the goal should be to leverage existing production infrastructure to the maximum extent possible, costs will remain. The U.S. government was still required to furnish some infrastructure and tooling requirements for educational orders in World War II. The DoD must be prepared to do the same within a manufacturing reserve program while also ensuring there is a proper incentive structure to attract companies. These concurrent requirements will likely incur a higher price tag than the initial $131 million proposed by Congress.

184 "Army Launches Detachment 201: Executive Innovation Corps to Drive Tech Transformation," U.S. Army Public Affairs, June 2025, https://www.army.mil/article/286317/army_launches_detachment_201_executive_innovation_corps_to_drive_tech_transformation.

- Cost-benefit research is needed to assess whether future industrial conversion programs offer enough advantages to justify their costs. This analysis can inform decisions on striking a balance between affordability and long-term readiness.

Although the modern DIB and U.S. industrial landscape are both very different from those of World War II, a well-funded, well-implemented industrial conversion program still has a place in future mobilization plans. Policymakers have the advantage of hindsight over their predecessors. They can use the lessons identified from World War II to establish more deliberate industrial conversion policies at the national level in peacetime, regardless of whether they adopt the reserve manufacturing model. These policies would require the DoD and industry leaders to dispel many current acquisition and industry norms, just as the War Department and the automotive industry did in the 1940s, to ensure that the United States is prepared for protracted warfare with a peer adversary.

LIST OF ACRONYMS

ACWP	Automotive Council for War Production
ANMB	Army and Navy Munitions Board
CMP	Controlled Materials Plan
CPFF	cost plus fixed fee
CSBA	Center for Strategic and Budgetary Assessments
DIB	defense industrial base
DIU	Defense Innovation Unit
DPC	Defense Plant Corporation
FY	fiscal year
GAO	U.S. Government Accountability Office
GOCO	government owned, contractor operated
IMP	industrial mobilization plan
MOSA	modular open system approach
NDAC	National Defense Advisory Commission
NDIS	National Defense Industrial Strategy
ODM	original design manufacturer
OEM	Office of Emergency Management
OPACS	Office of Price Administration and Civilian Supply
OPM	Office of Production Management
OT	other transaction
PRP	Production Requirements Plan
SPAB	Supply Priorities and Allocations Board
WPB	War Production Board

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