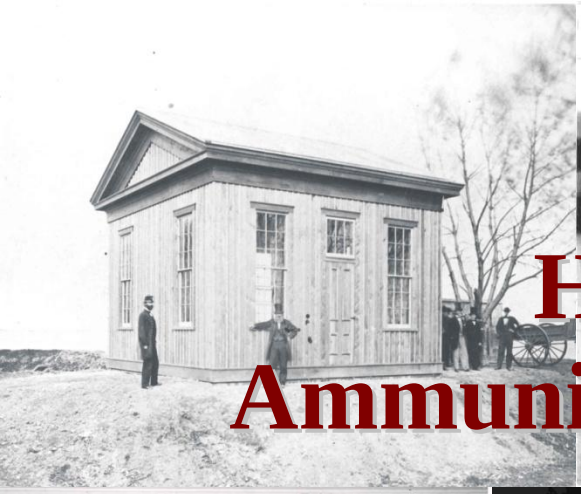

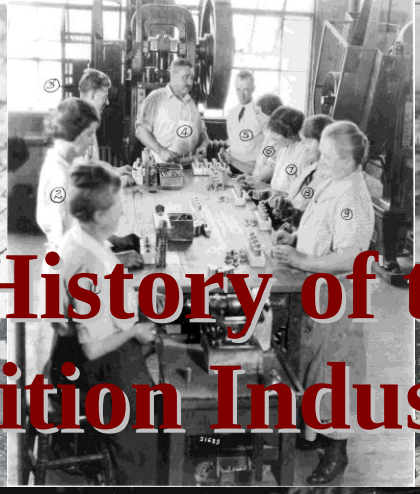

History of the Ammunition Industrial Base

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Front Page Photo Captions

Starting at Top, Left to Right across

1. Experimental laboratory at Frankford Arsenal in Philadelphia, PA in 1864.
2. .30 caliber tracer round unit workload table at Frankford Arsenal circa World War I.
3. Old Hickory Powder Plant constructed during WWI to supply powder and explosives to U.S. Forces and Allies.
4. Pictured just below is Nitro Powder Plant in West Virginia which operated during World War I.
5. Picture of Munitions Command (MUCOM) executive event during the 1960s. MUCOM is a predecessor command of the Joint Munitions Command.
6. Employees produce .50 caliber ammunition at Lake City Army Ammunition Plant during World War II.
7. Popular Norman Rockwell poster that expressed supplying Soldiers with enough equipment and ammunition on time at the right time during WWII.
8. Twin Cities Army Ammunition Plant (AAP) employees on a .50 caliber linked production line during the 1960s.
9. Artillery being shot from howitzer during Vietnam Conflict.
10. McAlester Army Ammunition Plant production line circa 1960s.
11. Radford Army Ammunition Plant, a propellant and energetics production plant operating from 1942 to present day.
12. 1990 BRAC deactivation and closing ceremony at Joliet Army Ammunition Plant.
13. Quality Assurance Specialist Ammunition Surveillance (QASAS) ammunition inspection during Operation Iraqi Freedom (OIF).

History of the Ammunition Industrial Base
From Creation to Present Day

Ammunition is a unique commodity that requires technical production accuracy to exact specifications and superior quality levels for the safety of its users. To accomplish this mission a network of government owned contractor operated (GOCO) and government owned government operated (GOGO) ammunition industrial sites has evolved over time to produce superior munitions for all U.S. military Services and Allies. The U.S. Army ammunition industrial base has experienced great degrees of transformation over the past half century. The base has experienced the largest of expansions during World War II (WWII) to the lowest levels of reduction during the current Global War on Terrorism (GWOT)[1], now referred to as Overseas Contingency Operations (OCO). Reasons for the reduction include factors such as modernization of production technology and more peaceful periods of history. The following history examines the evolution of the industrial base, emphasizing the changes and provides rationale for the gradual decrease in the size of the ammunition industrial base from WWII to 2010. This report addresses specific challenges in regards to right-sizing the industrial base, which leads to the frequently debated question: what should the ammunition industrial base look like for the future?

The ammunition industrial base is a complex system composed of contractors, subcontractors, government owned and government operated (GOGO), and government owned and contractor operated (GOCO) facilities. The government owns key facilities to manufacture propellants and explosives and to load, assemble and pack (LAP) munitions with contractors operating most of the facilities and operations.

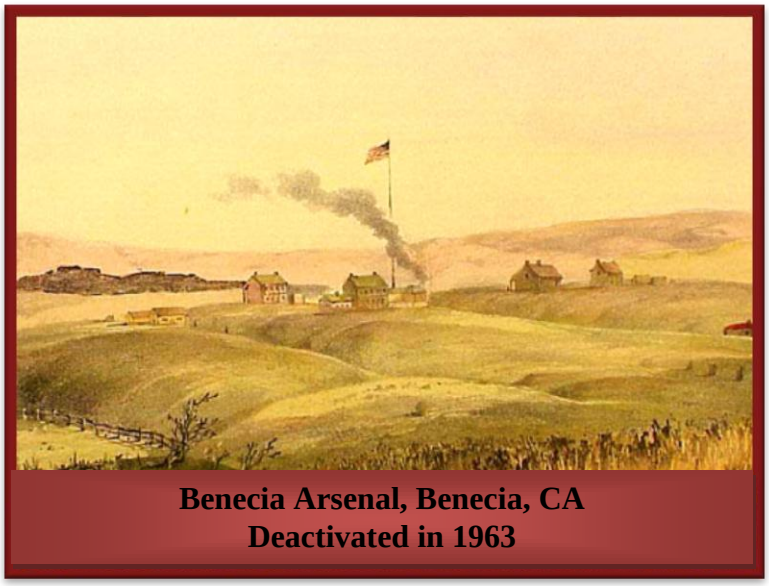
The current munitions base evolved from the large base established to meet the demands of WWII. The base evolved to meet the Korean Conflict, Vietnam Conflict, Cold War tensions, and ongoing conflicts in the Middle East. The base has been reconfigured several times to meet projected requirements, to accommodate changing weapons technology, and to incorporate improved manufacturing methods. The challenge for managers of the conventional ammunition base is to create the proper balance between two competing needs - the need to maintain the reserve capacity required to replenish the war reserves after a major conflict and the need to economically meet peacetime requirements. To fully understand the situation and state of the current ammunition industrial base, a closer look at its origins and evolution is necessary.

The Ordnance Department (OD)

The Revolutionary War taught the Nation its first lessons in material mobilization. Successful war conduct was linked to the availability of war-fighting supplies and equipment. The leaders of the Continental Army realized that efforts were needed to organize, produce, manage, and supply the Nation's Army if it were going to gain independence and win the War against England. In November 1775, Colonel Henry Knox established one of the firs U.S. industrial base capabilities. He selected Carlisle, Pennsylvania as the site for the first Continental Army Depot Arsenal. Carlisle, along with approximately 27 other depots and arsenals, stored and maintained supplies for the Continental Army during the Revolutionary War.

[1] GWOT is now referred to as Operation Enduring Freedom (OEF), Operation Iraqi Freedom (OIF), and Operation New Dawn or Overseas Contingency Operations (OCO).

Immediately after the war, the Army faced dramatic cuts in military expenditures, causing major cuts in military production. This caused material and equipment shortages and readiness impacts for the War of 1812. To combat material shortages, an Act of Congress established the Ordnance Department in 1812 to conduct the business of providing material of war. The first funding made available to the Ordnance Department was in the amount of $20,000 to use for implementation with succeeding years authorized at over $870,000. The Ordnance Department owned a small collection of manufacturing and storage facilities throughout the period of activation. At the brink of War, despite the new organization of the Ordnance Department, the military found themselves unprepared to face conflict. In 1812, there were only four installations available to the government for the manufacture, repair, storage, and issue of ordnance materiel.[2]



Benecia Arsenal, Benecia, CA
Deactivated in 1963

Over the years leading up to the Civil War, the Ordnance Department and infrastructure continued to grow. By 1832, eleven arsenals and two armories existed.[3] In 1832, the Ordnance Department acquired three additional installations and added six more facilities over six years, mainly in the south eastern region. By 1851, ordnance spanned the continent with the establishment of Benicia Arsenal in California. By 1860, the country had expanded in size to over 3 million square miles. The national population doubled to over 30 million and expanded westward beyond the Appalachians Mountains and Mississippi River. This expansion had direct logistics effects on supply lines. Supply lines were longer and the theater of operations was now larger than the U.S. had ever experienced. Ordnance infrastructure and operations grew to keep pace with national development; however, the build ups were small in comparison to the actual requirements that would be required by the expanded force that fought the Civil War, Spanish American War, and World War I.

The Arsenal System

The Civil War brought on enormous wartime expansion and served as a great test for the Ordnance Department. The rapid expansion of Union forces to a million man force created an unparalleled field service support mission in American history. Almost overnight the Ordnance Department faced supply challenges. In 1862 the Ordnance Department presented the "grand arsenal" concept. The concept plan envisioned a grand arsenal in the East. The idea consolidated operations into one large Arsenal complex and would take over missions being conducted at Springfield Armory which produced small arms and small caliber ammunition. In exchange for "the grand arsenal" several existing arsenals such as Allegheny, Columbus, Detroit, Pikesville, Watertown, and Watervliet would be sold. After consideration this plan was not implemented, however it is apparent that even in the Civil War period, when military ordnance

[2] Ordnance Department. *Ordnance Corps History (OCH)* Volume I, 46.
[3] *Ibid*, 46.

infrastructure was just beginning to be built up, policy and decision makers sought to reduce the size, consolidate, and modernize the industrial base.[4]

Arsenals were built primarily to address peacetime needs. Arsenals were the solution for sustaining research and development in the new industrial age and preserving needed personnel skill sets during peacetime. The existing ordnance arsenals sufficed to supply the Army with training and reserve requirements in peacetime. Arsenal production capacity was never large enough to meet wartime needs, but each arsenal provided technical assistance and expertise that was invaluable when industrial expansion was required.[5] Frankford and Picatinny Arsenals were responsible for ammunition components and end items; they operated low production levels and performed research and development. Blueprints, SOPs, shop layouts, and other important technical information were maintained along with a small workforce to provide retention of special skill sets. It is from the arsenals that the ammunition industrial base has been rooted and built. As technology and weaponry advanced and requirements grew, it became necessary to segregate the ammunition mission from the arsenals and create an independent ammunition industrial base.

As arsenals concentrated on maintaining a peacetime level of production, the Ordnance Department prepared to contract for additional production capability in the event of a war. However, reliance on contractors alone would not satisfy the urgent ammunition requirements the U.S. faced in upcoming wars. The story of the Ordnance Department industrial base becomes more complex through time, but the focus of this report will now turn to WWI, when ammunition commodities were segregated from the rest of the ordnance supply system.[6] Prior to World War I (WWI) the nation relied on smaller government owned facilities and limited commercial industry to support the War Department's ammunition requirements. Due to the relatively small size of the military, such arrangements were satisfactory. WWI placed extreme stress upon the system and required additional commercial support.

World War I

The U.S. entered WWI with little advance planning for the expansion of ordnance industrial bases. Prior to the conflict, the U.S. relied on mostly foreign companies and private suppliers to meet ammunition needs. The worldwide scope of war and national mobilization led to the establishment of the War Industries Board (WIB) to regulate civilian and government military procurement and production. The need for the development of an industrial base from which the materiel of war could be obtained had been cited in the annual reports of the Ordnance Department for many years before WWI.[7] Thus, the outbreak of hostilities in Europe further urged the need to expand plant capacity and capability for the production of munitions.

In April 1915, a board of officers was assigned to analyze the Army's stock of field guns and ammunition. The board reported that conditions looked bleak if the Ordnance Department did not take action before outbreak of hostilities with a powerful nation. They also discussed the weakened condition the U.S. could suffer from if Eastern facilities near the coast were captured

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[4] OCH Vol I, 44-46.
[5] Ordnance Department. *Ordnance Corps History (OCH)* Volume II, 17.
[6] Ammunition was previously managed with other commodities such as weapons. Leaders realized the complex nature and uniqueness of ammunition, and began to manage it separately vs. with other materials and supplies.
[7] OCH Vol I, 110.

by enemy forces. Despite scenario planning, the industrial base still needed modernization and at least 18 months would be required before production output could meet the demands of modernized warfare.[8] Facilities were inadequate to meet wartime requirements in the event of a national emergency or wartime crisis. In addition, establishing manufacture of munitions in shops unfamiliar with the technical accuracy necessary for ordnance material, was a technical challenge that could take months. The Chief of Ordnance commented on additional challenges, "the element of money was not alone a limiting factor. Had appropriation of essential funds been made - it could not have brought munitions instantly into being…commandeering of machine tools was impossible; they were non-existent. No funds were available for the tooling – and in consequence no contracts could be made…"[9] Despite the planning committee's analysis and problem recognition, resulting actions would not be implemented in enough time before U.S. involvement in WWI.

When U.S. representatives met with Great Britain and French leaders, the U.S. decided to answer the call to commit troops to operations overseas. An international ordnance agreement was created. The agreement reflected the need for U.S. to build up all aspects of its munitions industry. As U.S. troops were committed to the theater, Great Britain and France agreed upon supply of equipment and ammunition. It was still critical for the U.S. to build up its military industrial base to sustain requirements and troops. The agreement also indicated that Great Britain and France required immediate support in the production of large amounts of propellants and explosives. It is interesting to note that plans for mobilization of men were readily available at the Army War College, but no plans existed for the equally important task of mobilizing industry and production of munitions.[10]

Supporting the requirements of WWI proved difficult because of the lack of industrial mobilization planning. The Ordnance Department carried the explosives and propellants production program further toward completion than any other commodity. Manufacture of explosives and propellants had already been underway when the need to increase production arose. The U.S. had to build up the plant base to meet its own requirements and those of Allies. Smokeless powder and high explosives were one means of paying munitions debts to Allies, therefore we were already producing in large quantities during WWI. After further U.S./Ally agreements were made an additional 53 new plants for explosives, propellants and loading were built at a cost of around $360M. During the 19 months of war, the buildup enabled the U.S. to produce more powder than Great Britain and France combined. For an idea of how much production increased, consider the fact that pre-war production of smokeless powder had been about 18 million pounds. During war, the U.S. alone produced over 273 million pounds of powder and 375 millions pounds of high explosives.[11] The nation's prewar production capacity of TNT was only 1 million pounds a month and increased to 16 million pounds a month by the time of the Armistice. Improved methods and quantity production increased output dramatically during the war.[12]

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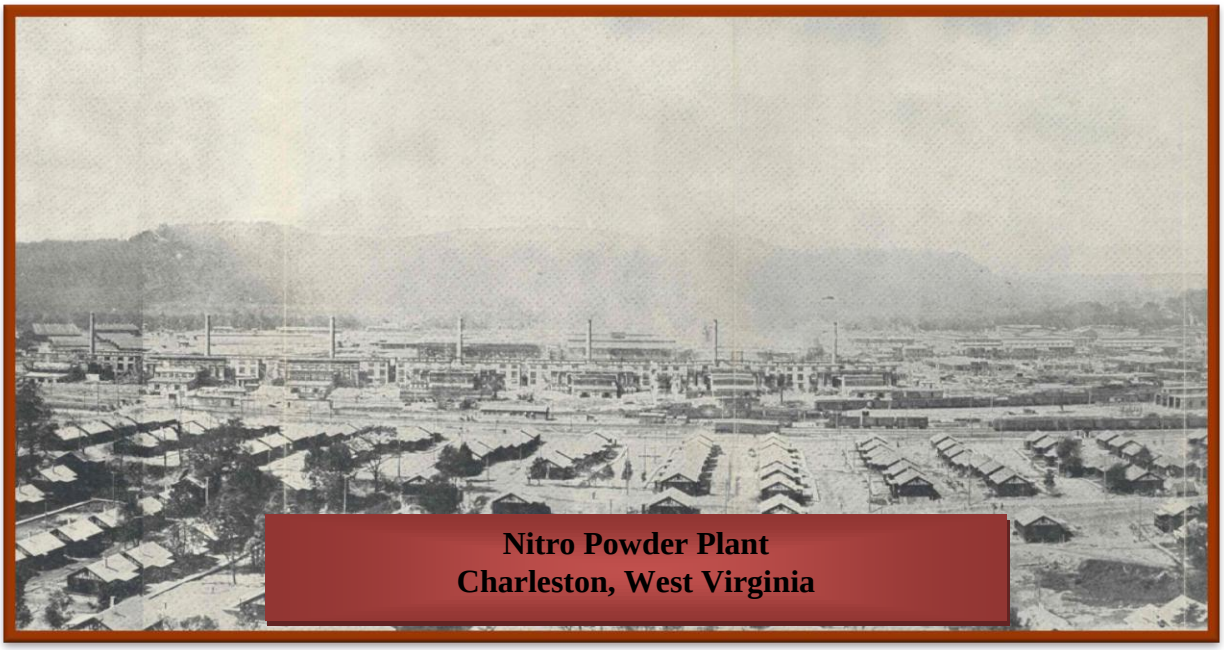
[8] OCH Vol I, 110-115.
[9] *Ibid*, 111.
[10] Benedict Crowell. *America's Munitions 1917-1918: Report of Benedict Crowell: The Assistant Secretary of War and Director of Munitions.* (Washington, Government Printing Office: 1919), 18.
[11] OCH Vol. I, 140
[12] *Ibid*, 141-143.

By the end of the war the War Industries Board (WIB) had constructed sixteen plants for powder and explosives manufacture. The sixteen government facilities combined with commercial producers totaled 92 plants manufacturing powder and high explosives; of which 28 made ammonium nitrate, 15 picric acid, 13 smokeless powder and 11 TNT. An additional 93 other plants were loading, assembling, and packing shells, bombs, grenades, boosters, fuzes and propellant charges.[13] The number of employees needed to operate explosives plants during WWI was phenomenal. For example, the four largest explosives plants employed around 35,000 laborers total. Two of the largest WWI smokeless powder plants were Old Hickory Plant near Nashville, Tennessee and the Nitro Plant near Charleston, West Virginia.

Old Hickory Powder Plant
Near Nashville, TN



Nitro Powder Plant
Charleston, West Virginia

[13] OCH Vol I, 142.

At the beginning of WWI, no machine gun or machine rifle had been accepted as a permanent standard for the U.S. Army. After various models were tested in training and several brands were implemented for use, the Army determined they needed a standard. The introduction and acceptance of a standard American Browning machine gun escalated small caliber ammunition requirements during WWI. New methods of combat made the development of several special types of small caliber ammunition necessary to include: tracer, incendiary, and armor piercing ammunition.[14] The need for more types and greater amounts of small caliber ammunition was initially met by Frankford Arsenal, the only U.S. production facility capable of mass quantity production. Several commercial plants were producing on smaller scales as well.[15] As soon as all available capacity was utilized, the Ordnance Department expanded existing facilities and lines at Frankford, built new ammunition plants, and trained more personnel to meet wartime demand.

At the cessation of hostilities in November 1918, immediate action was taken to decrease the manufacture of munitions. Most forging work ceased, and no further production of raw or semi-finished materiel was allowed. At the end of WWI, commercial industry abandoned any munitions support as the U.S. peace movement branded them "merchants of death" and accused the industry of reaping great profit.[16] The commercial and government owned ammunition base was almost completely dismantled. The manufacturing plants erected by the government were mostly sold to the previous owners of the land they had been built upon. Machine tools were disposed of or sold to consumers. America was eager to live in peace and shed its arms hoping that war would not return.

Planning Between Wars

WWI lessons provided warnings of long mobilization should the U.S. confront another major war. The War Department took limited action and began planning for future industrial mobilization. For the first time, an official was assigned to prepare plans for the mobilization of productive resources of the Nation behind the military and naval operations of war. First task was to plan and address policy on what stocks of munitions and what manufacturing facilities were to be maintained for the future. In the summer of 1919, the Chief of Ordnance appointed a Munitions Board to assess the future of the industrial base. The board formed recommendations and plans for storage and maintenance of ammunition which could have provided a stronger peacetime infrastructure. However, the General Staff and the Secretary of War failed to act upon many of the board's recommendations. Instead, the Ordnance Department (OD) followed War Department orders to store and maintain far larger quantities of munitions than the Munitions Board believed could reasonably be marked as primary reserve. This reserve affected scheduling for the future manufacture of new ammunition.[17]

The National Defense Act of 1920 made the Assistant Secretary of War responsible for industrial mobilization planning and procurement. The legislation recognized the need for national defense preparedness. Though the primary thrust of the law dealt with Armed Forces personnel strength, it contained important provisions for organization reform and mobilization

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[14] OCH Vol I, 146.

[15] Crowell, 191-193. See Crowell's book for longer explanation of WWI small cal industrial base info.

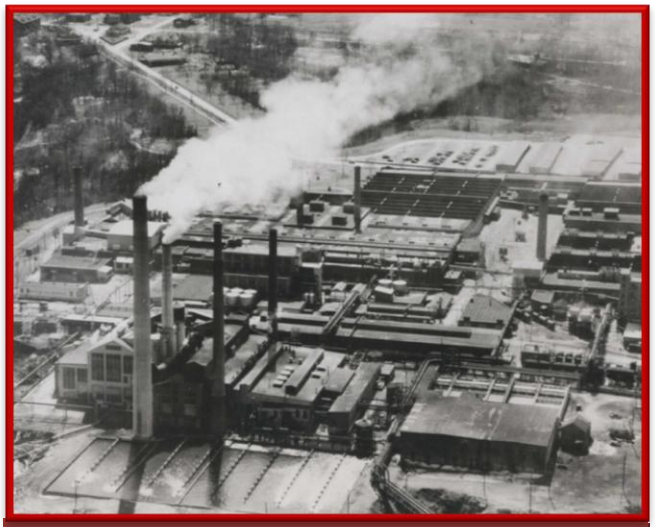
[16] Harry C. Thomson and Lida Mayo. *United States in World War II: The Technical Services – The Ordnance Department: Procurement and Supply.* (Center of Military History, Washington D.C.: 1960), 107.

[17] OCH Vol II, 13.

planning. Responsibility for procurement of military supplies and the mobilization of material and industrial organizations were explicitly assigned to the Assistant Secretary of War. The Assistant Secretary of War then reorganized his office to include a Planning Branch. This staff with the Army and Navy Munitions Board exerted strong influence upon the Ordnance Department's planning between world wars. The fact that peacetime mobilization planning was happening at all was a major accomplishment and step forward for U.S. military readiness. In the 1920s several mobilization plans were finished and modified. Thereafter, new mobilization plans were generated on average every four years.[18]

Despite planning efforts, storage and maintenance of ammunition brought great challenges between WWI and WWII. More money was earmarked for maintenance of the war reserve than for any other purpose. Of the total sum, about 60% of the ammunition budget was spent annually for ammunition preservation. To maintain a useable War Reserve, periodic surveillance of stocks and careful testing of representative lots to detect incipient deterioration was necessary. Ammunition lots that were unserviceable had to be renovated or replaced. In 1926, Public Law 318 authorized exchange of deteriorated ammunition for new, but adequate funding for renovation continued to be hard to obtain. Despite the yearly attempts of ordnance spokesmen to explain the chemistry of ammunition deterioration, Congressmen found the argument unconvincing. By 1928, a special program of surveillance and renovation was started. The OD exchanged 4 million pounds of unserviceable powder for 350K pounds of new flashless powder and also opened the first special renovation plants. Up to WWII, leaders continuously debated whether it was better to renovate old stocks than to buy all new ammunition. In October 1938, the Ammunition Supply Division of Field Service estimated it would cost $19 million to renovate the ammunition items required to meet the war reserve for the Initial Protective Force. The OD decided to renovate artillery ammunition stocks, but realized future war requirements would require a large build up of the base.[19]

Throughout the 1920s and 1930s research and modernization lagged. The DuPont Company was visionary in that they operated the nation's sole TNT plant at low production levels in order to maintain the equipment, process, and expertise.[20] As ammunition supplies were expended, there was no major resupply or modernization effort. At the same time, developments in weapons and doctrine, primarily abroad, rendered much of the stored ammunition obsolete. Poor storage conditions led to the deterioration of viable modern stocks and Congressional budgets for ammunition were at a starvation rate. Thus, the ammunition stockpile was not maintained properly.



Old Hickory Powder Plant – DuPont bought the plant from the Government in 1923
Near Nashville, TN

[18] Harry Thomson & Peter Roots, *US Army in World War II The Ordnance Department: Planning Munitions for War* (Center of Military History, Washington D.C.: 1955), 30, 32, 50.
[19] OCH, Vol II, 10-18, 22-24.
[20] Berkley R. Lewis and C.B. Rosa, Office of the Chief of Ordnance, *History of the Ordnance Department in World War II, Monograph 4, Ammunition*, 31 December 1945, 5.

In 1929 a special survey called attention to several defects in past mobilization plans. The survey discussed failures to apply WWI lessons that indicated it took at least a year longer to arm men for fighting than to mobilize and train them for actual combat. The survey stated, "…it will be noted that in all munitions phases there is a wide gap between the exhaustion of the present reserve and the receipt of munitions from new production." [21]

By 1937, more attention was devoted to ammunition industrial base issues. Increasingly aware of possible air attacks, a study was conducted to project the best and safest locations for future ammunition facilities. The study considered strategic locations, proximity to strategic raw materials, transportation facilities to probable theaters of war, economy of operation and climate. In 1938 Congress passed the Educational Orders Act. This act permitted the OD to place orders with allocated facilities for small quantities of hard to manufacture items. The act gave selected manufacturers experience in producing munitions and to ability to procure essential tools and manufacturing aides. By 1940 over eighty educational awards were granted.[22] As war commenced in 1940, the U.S. converted existing educational orders into production orders. Contractors and ordnance officials valued the program and believed in its ability to increase industrial preparedness. In April 1941, reports indicated that over half of the companies that received educational order contracts received production orders. The educational orders were an essential program that spread knowledge of specialized ordnance manufacture capability to around 82 companies and acted as a springboard for remobilizing industry at the start of WWII.[23]

Though many improvements were made in mobilization planning, analysts are critical of the inter-war period and think more could have been done to prepare for future conflicts. R. J. Hammond wrote a *Profile on Munitions WWI-SEA* (Southeast Asia) and was critical of the lack of mobilization planning during this peacetime period. He quoted President Franklin Roosevelt who stated, "When the chips are down, no amount of priming will do the job if the pipes have been allowed to rust away, equipment and buildings have been allowed to deteriorate, or the expertise necessary to operate such facilities are lost to other industries or forever." Hammond repeatedly talks about how the Ordnance Department ignored demands/recommendations and the base was not maintained during this period.[24] In *The Ordnance Department*: *Planning Munitions for War* the authors indicated that from 1920 to 1940 plans were always shaved down, operations were restricted and projects were frequently stopped short of completion, all because of lack of money.[25] In *Peacetime Industrial Preparedness for Wartime Ammunition Production,* Harry Ennis wrote that the interwar period resembled an "interesting ambivalence" in the presence of national security considerations. On one hand, voices were raised in the plea that the Nation should never again find itself unprepared for war. On the other, strong political sentiment indicated that maintaining large reserves and preserving the industrial base were unfavorable to the policy of neutrality.[26] No matter what the arguments were, it is clear that the Ordnance Department did not receive the funding needed to keep the base sustained and their recommendations were not adopted wholeheartedly by the War Department or Congress.

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[21] OCH Vol I.
[22] Thomson and Mayo, 20.
[23] *Ibid*, 19, 123.
[24] R. J. Hammond. *Profile on Munitions: WWI-SEA 1950-1977*. (ARRCOM Historical Office, Rock Island, IL), passim.
[25] Thomson & Mayo, 31.
[26] Harry Ennis. *Peacetime Industrial Preparedness for Wartime Ammunition Production*. (National Defense University, 1980), 30-32.

Despite shortfalls, when the threat of WWII surfaced in the summer of 1940, the Ordnance Department mobilization planning created a level of readiness never before achieved in prior U.S. mobilizations. Their accomplishments included industrial requirement estimates for a major war. They created the Army Industrial College to train officers in the tasks of military procurement and industrial mobilization. They set up procurement districts and zones to decentralize and expedite the gathering of procurement information and the planning of procurement operations. They arranged a systematic survey of industrial facilities and assigned those facilities to the appropriate Technical Services. They studied WWI and learned from shortages and problem areas that they focused on to prevent repeated mistakes. They studied legislation and administrative problems that the Nation's resources might present in the future and created procedures to deal with them. They also produced an Industrial Mobilization Plan, a blueprint for the control of the Nation's resources in time of war.[27] The initiatives and accomplishments provided invaluable administrative gains needed in the preparation for involvement in WWII.

With the limited number of commercial producers, the best solution to meet future munitions requirements would be to build new government owned contractor operated (GOCO) plants for WWII. Within each passing year, the Ordnance Department (OD) directed more attention to developing plans for the speedy conversion of private industry to new munitions producers during wartime. By 1940 the American public attitude was changing, and people demanded a more adequate national defense. The U.S. had plants operating prior to U.S. entry into WWII due to the foresight of the OD and alliance needs. In 1937, the OD established joint military-commercial planning officers for explosives and propellants. These offices were charged with developing plans for the construction of plants for explosive, propellants, and required chemicals. Similar offices were established to focus on artillery, bomb, fuze, and small arms component assembly. The offices were assisted by planners from Dupont and Hercules Powder as well as other experts from the limited commercial ammunition base. They considered all aspects of plant layout to include relationships with suppliers, transportation, safety distance, and line flexibility to respond to fluctuating requirements.

The OD initiated these talks because they understood they'd have to create relationships between the War Department and commercial industry to produce ammunition for a global war. While other ordnance items and quartermaster supply requirements like trucks, airplanes, tanks, and rifles were more easily made in the commercial plants, there were only a handful of small commercial ammunition producers. For products like smokeless powder, TNT, ammonia, artillery and small arms ammunition, there were no existing government plants that could be readily converted. Because ammunition plants offered none of the usual attractions for private industry and capital, the OD recognized they would have to build at government expense. Ordnance engineers, the small peacetime explosives industry, Frankford and Picatinny Arsenals all cooperated and drew up plans and specifications for plants to be built rapidly in response to WWII.

The OD was committed to building a government owned ammunition base, but realized that not all production would have to occur in GOCO plants. Based on analysis and industry input, they were able to limit GOCO facilities to propellant and explosive production to include required chemical manufacturing processes, while private industry made most metal parts. In

[27] OCH Vol. l, 5.

addition to planning the number of plants required, OD also developed plans for other use of private industry. The OD conducted industry surveys of all major industrial plants. Not only did the survey record what the plants made, types of equipment and floor space, the OD also investigated finances, resources, types of workers, transportation networks and more. The OD was interested in companies with good management and engineering. One key planner stated: "It was not just the machines and floor space that counted. Of even greater importance were the men – skilled workers, the production engineers, the executives who understood the secret of high-quality mass production."[28]

When the British could no longer pay cash for arms and munitions in December 1940, President Roosevelt suggested leasing or lending war supplies to those fighting the Axis. He likened it to lending a garden hose to a neighbor whose house was burning. Once the fire was out, said President Roosevelt, "he gives it back to me and thanks me very much," or, if damaged, he replaced it. For three months Americans debated the Lend-Lease bill in Congress. Isolationists condemned it as leading America into another European war, as in World War I. But many Americans saw the need to aid Allies. Numbering the bill H.R. 1776 gave it a patriotic aura, and Lend-Lease act was passed. Signed into law in March 1941, Lend-Lease permitted the president to "sell, transfer title to, exchange, lease, lend, or otherwise dispose of" defense articles to "any country whose defense the President deems vital to the defense of the United States." Congress initially appropriated $7 billion, with a total expenditure of more than $50 billion by the end of World War II. The initial expansion of the WWII era industrial base production came from orders placed by Britain and France. [29]

World War II (WWII)

World War II (WWII) required the largest ammunition base buildup in history. When war broke out in 1941, ammunition manufacturing was already moving forward. A network of ammunition plants were built across the country between June 1940 and December 1942. Representing a capital investment of about $3 billion, a wide range of chemicals, artillery ammunition, bombs, grenades, rockets, mines, small caliber ammunition, powder, and explosives were produced in the industrial complexes. The annual operating expenses amounted to over $1 billion. Huge tracts of land were bought and utilized for explosives, propellants and loading plants because of production safety requirements. Despite mobilization planning, it took until late 1942 and early 1943 for the industry to catch up with Army requirements.

Flag Raising at Radford Ordnance Works, Virginia

As a first order of business, Congress authorized $3 billion to build explosive and propellant plants in 1939. There were only a half dozen

[28] JMCR 10-1 Regulation. JMC History Appendix.

[29] Thomson & Mayo, 156; "Lend Lease Act 1941" Accessed at: http://www.ourdocuments.gov/doc.php?flash=true &doc=71.

companies in the U.S. with experienced personnel to produce explosives, and the capacity of smokeless powder production had fallen to only 30 tons a day and TNT was lower at 12 tons a day.[30] Therefore, a large proportion of Ordnance funding obligated during the latter half of 1940 went to new powder and explosives plants and for plants that loaded, assembled and packed (LAP) artillery. The OD signed its first contract with Dupont for construction of a smokeless powder works (Indiana Ordnance Works). Another contract was approved for the construction of Radford Ordnance Works in Virginia with Hercules Powder Company as the operating contractor. By December 1940, a full year before Pearl Harbor, 22 new facilities were under way for shell loading and production of chemicals and explosives.[31]

By October 1941 several ammunition complexes were producing ammunition. By the end of 1941 there was at least one of every essential type of government owned ammunition plants incorporated into the industrial base to include TNT, DNT, tetryl, toluene, anhydrous ammonia, smokeless powder, bag loading, and shell loading plants.[32] After Pearl Harbor, an additional 25 facilities were authorized almost immediately and construction began between January and August 1942. A total of 112 plants were authorized and 84 were constructed in only a few years.[33]

The need for expansive buildup did not go unquestioned. The Truman Committee of the Senate and the Tolan Committee of the House of Representatives expressed criticism in 1941. They thought the building of new plants was needless and the Ordnance Department was failing to fully utilize existing capability. They viewed Army procurement efforts as "helpless" in dealing with large corporations who were refusing to convert to wartime production. This perceived helplessness drove demand for new plant construction. They claimed the Army wasted building materials, contributed to machine tool shortages, and delayed production.[34] The committee may have been justified in their arguments; however, they failed to understand that the new construction would be for a bulk of ammunition commodities that simply could not be met through procurement efforts. In December 1941, the Under Secretary of War, Robert Patterson, defended Army proposals and answered the critique by the Senate and the House. [35] The Secretary vigorously defended construction of ordnance facilities and assured the Committees that the Army had not proceeded with base expansion of new plants except where necessary. These criticisms were quickly forgotten after the outbreak of war. What appeared to be over expansion in the fall of 1941, took an appearance of under expansion after Pearl Harbor. Wartime requirements escalated rapidly and placed strain on all existing ordnance facilities.[36] By the time of the Pearl Harbor attack, it took an average of 9-11 months between contract and first operations when bringing a new capability on line.

Despite the large numbers of plants, attempts at efficiency were being practiced. In several cases plants turned out more than one product. For example Badger Ordnance Works (BOW) in Wisconsin was constructed to produce three smokeless powder lines but was revised

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[30] Hammond, 3.
[31] Thomson & Mayo, 110-111.
[32] Hammond, 105.
[33] Hammond, 3; Thomson & Mayo, 110-113.
[34] Thomson & Mayo, 33.
[35] Records of the Under Secretary of War. Accessed at: http://www.archives.gov/research/holocaust/finding-aid/military/rg-107-2.html.
[36] Thomson & Mayo, 33.

to add double base powder. Flexibility was essential because the requirements were constantly changing. As requirements rose or fell, plants shifted production from one type of ammunition to another, production lines shut down, new lines were added or entire plants were shutdown. For example, in the summer of 1942, a bag loading plant in Flora, Mississippi was almost completed when the OD suddenly decided it would not be needed. Instead, the plant was converted into a unit training center until 1945. When heavy artillery ammunition requirements rose again, plans changed again and the plant was then used as originally intended.

Almost all government ammunition plants were operated by contractors. It was not uncommon for large mass producers such as Coca Cola, Quaker Oats, or Eastman Kodak to operate a military industry. Companies like the U.S. Rubber Company operated ammunition plants with no prior experience. Despite lack of ammunition experience, large conglomerate companies were seen as capable of transferring mass production experience and managerial practices into the munitions business.[37]

Decentralization of the Ordnance Department procurement and administration during WWII led to the creation of the Field Director of Ammunition Plants (FDAP) headquartered in St. Louis, MO and the Small Arms Ammunition Sub Office at Philadelphia, PA (attached to Frankford Arsenal). This sub office was under control of the Small Arms Division in Washington, and it coordinated small arms ammunition production in a similar fashion as to how FDAP coordinated production of artillery ammunition. In 1942, all control of the ammunition plants was transferred from the OD to the newly created FDAP. From the outset, the OD leaders assumed that FDAP would be an administrative and legal office dealing with technical problems that would be passed on to Picatinny Arsenal for resolution. In the beginning FDAP had no control over inspection, packaging, renovation, or scheduling but gained these responsibilities over time. By 1945, FDAP completely controlled and managed the GOCO plants previously under the Ammunition Division of the Ordnance Department.[38]

Few of the plants under FDAP supervision ever had a chance to achieve full efficiency and operating capacity. In most cases, as soon as a plant came into production and completed a few months of prove out operations, it received notice to curtail production. By the fall of 1943 officials throughout the War Department believed ammunition supply was adequate and that the OD produced too much ammunition. In January 1944, FDAP was forced to practice short range scheduling of plant operations with few schedules running for more than one month ahead. The lack of long range requirements forecasting made it impossible to concentrate production in the most efficient plants and operate them full time.[39]

Despite the challenges of creating an efficient and ideal ammunition base, some of the most remarkable technological advances of WWII occurred in the ammunition industry. The field was wide open for the development of new processes and machinery because there had been virtually no mass production of military ammunition over the previous two decades. Knowledge of powder and explosives production methods had been maintained by small scale production operations of powder and explosives at Picatinny and at small firms like DuPont. Pilot production lines at Frankford Arsenal served similar purposes for metal components. The OD experimented and found faster, more reliable production methods. During WWII, advances

[37] Hammond, 3-4.
[38] Thomson & Mayo, 125-129.
[39] *Ibid*, 125-129.

were made in the reverse nitration of TNT, toluene extraction from petroleum, mechanization of loading, and the development and use of wood pulp, RDX and rocket powder.[40]

During WWII doctrine had also evolved. U.S. Army field commanders paved the way for advancing foot soldiers by use of massed artillery fire and aerial bombing instead of exercising frontal infantry attacks. For example, in the first days of attacks on Cassino, U.S. artillery units fired around 11,000 tons of shells which were accompanied by fire storms of bombs from the air. Carpet bombing was also practiced across the theater. Therefore, expansion of the artillery ammunition base started on a modest scale in 1940. During 1941 expansion gained momentum as work on 25 new plants began and existing plant capacities were greatly increased. Thirteen of the new plants were for loading operations. Between January and August 1942, construction started on an additional 25 plants.[41] The rate of artillery expenditure during WWII required the operation of 60 artillery ammunition plants. See Appendix A for a listing of ammunition facilities to include small arms, explosive, propellant, and LAP facilities operated in WWII to support requirements.

In 1944, new ordnance directives ordered doubled the monthly production rate of artillery in seven months and to triple the amount in 14 months. The OD warned leaders of high expenditure rates and the need to produce more artillery and their predictions were accurate. Leaders reacted quickly and continued building up the artillery base. Several plants that had been shut down were reopened and re-equipped at record paces. During early 1945, heavy artillery expenditure rates reached record highs. The total for all types and sizes of artillery ammunition reached nearly 1 billion rounds. The value of artillery ammunition produced between Pearl Harbor and V-J Day was nearly $7 billion at 1945 prices. In addition, over one hundred million grenades and mines were produced along with 33 million bombs.[42]

In comparison to artillery production small caliber ammunition was simpler and easier to produce since it did not involve fuzes and loading of high explosives. Even so, the mass production of high quality small arms ammunition required equally exacting measures to meet quality specifications. Three major families of small arms ammunition were.30, .45, and .50 calibers with five main types: ball, armor piercing, armor piercing incendiary, incendiary, and tracer produced over the course of WWII. Before WWII, Frankford Arsenal was the only plant in the U.S. producing military grade small arms ammunition. Several commercial firms (Remington, Western, and Winchester) made sporting ammunition, but the difference between sporting and military ammunition was incomparable. In 1936 and 1937, ordnance reps met frequently with Remington Arms Company with goals to have Remington expand its capacity in the event of wartime emergencies and to also take over operation of proposed new government plants. After discussions, President of Remington, Mr. C.K. David, agreed with a formal statement of the plan drawn up by Frankford Arsenal. This was the first of many actions to rally commercial small caliber ammunition producers to augment government capabilities. The rate of small caliber expenditure during WWII required the operation of 16 GOCO plants.[43]

In the late 1930s, Frankford obtained funding for new machinery and equipment due to ordnance actions to modernize arsenals. In 1939, Frankford gained additional funding to expand

[40] *Ibid,* 133-144.
[41] *Ibid,* 107.
[42] *Ibid,* 105.
[43] *Ibid,* Chapter IX.

storage facilities and build a .50 caliber manufacturing line. It also used $800,000 to purchase specialized production equipment known as War Reserve Equipment to store for emergency use by the Remington Arms Company. To prepare commercial industry, Frankford also placed twelve orders for small arms ammunition under the Educational Orders Act in 1940-1941. Frankford extensively tested ammunition produced by these companies. Although the ammunition could not be used to fill wartime requirements, the initiatives greatly increased readiness in the commercial industry for conversion into military production. The need for .30 and .50 caliber ammunition increased dramatically for aircraft machine guns. Thompson machine guns increased .45 caliber ammunition requirements while British machine guns increased 9 mm needs. The existing commercial base and Frankford Arsenal could not reach sufficient capacity. Frankford steadily expanded facilities and increased production, but as requirements escalated, they could not satisfy the needed level of production and used the War Reserve Equipment it had specifically set aside for commercial industry for emergencies, in its own facility to meet demands. Leaders realized that immediate build up of the small caliber production base was imminent.

At first, ammunition requirements were unclear and initial production estimates were conservative. In fact, in July and August 1940 studies revealed requirements so high that the ordnance planners stopped to reconsider the whole subject. To meet the needs of a two million man force another three new plants were planned at a cost of $20 million each. The mobilization and construction time was estimated at 15 months. After study, small caliber ammunition industry expansion was planned in groups known as "waves." Five waves of plant build ups or alterations were initiated over two years. The first wave added small caliber ammunition plants commercially operated by Remington and the U.S. Cartridge Company in Lake City, MO, Denver, CO, and St. Louis MO. Production commenced by September 1941. The plant's combined capacities were over 300 million rounds a month; more than six times what Frankford produced. However, between 1940 and 1941, small caliber ammunition became the most critically short supplied item. The War Department, G-4 and Assistant Secretary of War urged the OD to open additional new plants as fast as possible. To meet increased demands, a second wave of three additional small caliber ammunition plants was approved by the War Department in April 1941. This wave of plants was less permanent in nature than the first three built in order to decrease construction time and production operations started only seven months from breaking ground. [44]

After Pearl Harbor in December 1941, requirements for small arms ammunition sky rocketed. One proposal called for 144 billion rounds by the close of 1944. Ordnance officials like General Charles Harris, Chief of Industrial Services, sensed the Presidential advisers' nervousness and urged patience and reassurance that the newly built plants could meet needs and possibly create an overabundance. Washington officials did not heed his advice and the Ordnance Department was directed to build 80 more production lines at three new plants. Twelve small arms plants were producing ammunition and the peak of wartime expansion had been reached. Total capacity was around 20 billion rounds a year.[45]

By 1943, ammunition production was drastically reduced. General Harris had been correct in his statement that "ammunition would be coming out your ears" with the proposed

[44] Thomson & Mayo, 195-196.
[45] *Ibid*, 199.

expansion set by Washington. He was correct, and by 1943 excess ammunition created storage problems. Plants were able to produce over and above initial estimates, and the mobile tank warfare in North Africa called for much smaller expenditure in rifle and machine gun ammunition than previously anticipated. In an August 1943 procurement review board, on hand stock of small arms ammunition in the U.S. was reported at 2.5 billion rounds. This was nearly equal to the American Expeditionary Forces (AEF) expenditures in WWI. It observed that the Day of Supply figures were excessively large, ammunition plants were operating below capacity, and reserves of ammunition were reaching "astronomical" figures. The Board concluded the War Department had to bring small caliber ammunition production back to "realms of reality."[46]

To eliminate excess production Frankford Arsenal returned its focus to laboratory work in 1943. Commercial operated plants converted to other war time needs and machinery was transferred elsewhere for work, stored or scrapped. Production of all types of small caliber ammunition dropped from 20 billion rounds in 1943 to 6.5 billion in 1944. Four factors were cited in the closures: 1) high rates of production attained by plants, 2) virtual elimination of the submarine warfare 3) effectiveness of .50 caliber incendiary ammunition in downing enemy planes and 4) Japanese evacuation of Kiska without a fight. Though the war was not over, the small caliber ammunition crisis had passed. [47]

After VJ day, all small caliber production plants except Lake City and Twin Cities were closed. Years later, the Korean Conflict would only require operation of six small caliber ammunition plants to meet wartime requirements. Five plants were utilized in the Vietnam War and amazingly today's production is able to meet requirements of 1.5 billion rounds per year by operating one facility, Lake City with Alliant Techsystems (ATK) as the current operating contractor. Modernization of production lines and new technologies has provided the abilities to meet this mission with a reduced infrastructure. Additional rounds are procured from General Dynamics and provided by NATO forces to meet total requirements. [48]

During WWII, requirements were difficult to determine in an era of changing warfare. Fluctuating requirements caused leaders to over and under estimate the readiness and quantity of inventory available for war. It is important to recall the nature of the times, as America experienced an attack on its own shores and the war expanded with the addition of a new front in Japan. Leaders were alarmed and were willing to pay the costs to ensure Soldiers were equipped and armed with ammunition to win the war and protect our borders.

Reducing the WWII Ammunition Base

Immediately after the defeat of Germany the Ordnance Department began closing down ammunition plants. After the defeat of Japan, the entire system was swiftly shut down. Around 50 plants, known to be excess, were transferred to the operating contractor or sold on the open market. Fourteen plants remained in an active status, primarily engaged in demilitarization, renovation, and the production of fertilizer. The remaining plants not excessed were placed in inactive status, decontaminated, padlocked and left without maintenance money.[49] In 1945 the

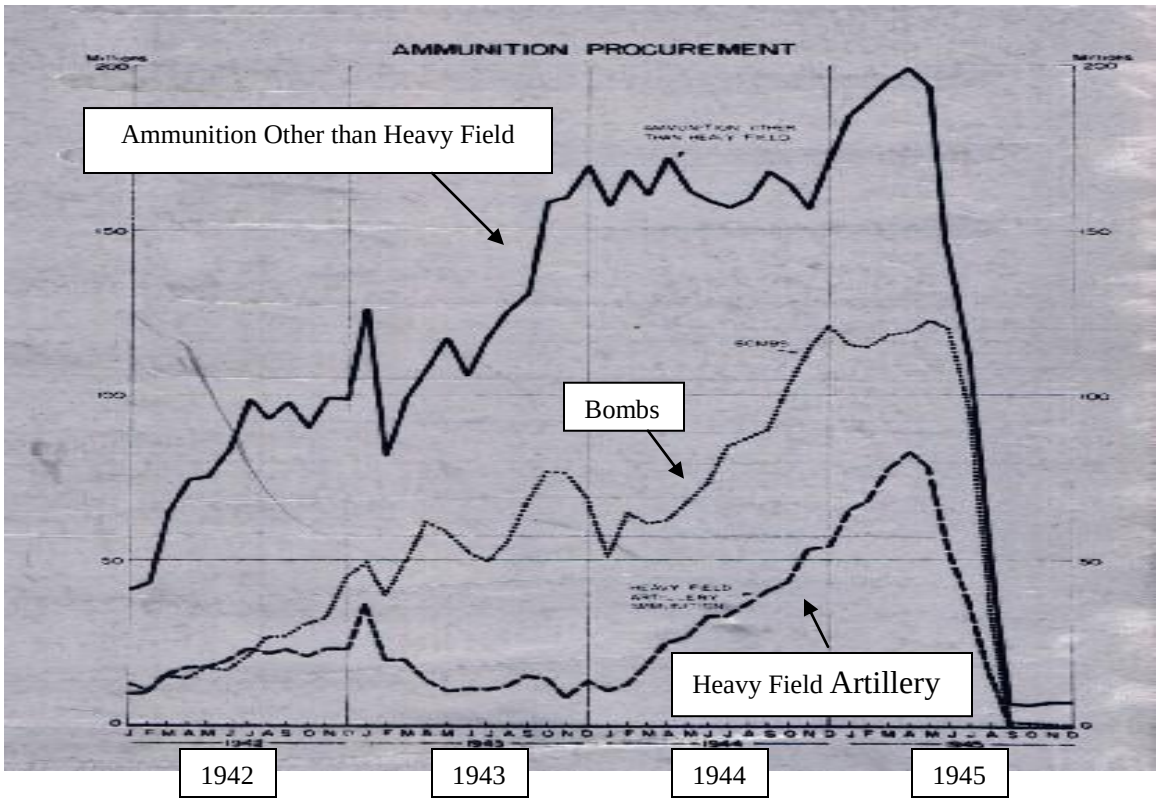
[46] Report of War Department Procurement Review, 31 August 1943.
[47] Thomson & Mayo, 219.
[48] PEO Ammunition. PM MAS Briefing, 2004.
[49] An inactive plant is placed in layaway status for future use. An excess facility is determined no longer required in the event of a future war, and are slated to be sold, dismantled or turned over to the Federal government.

number of GOCO plants was reduced from 84 to 38 and continued to decrease.[50] Increased tensions between the U.S. and Soviet Union caused by the Soviet aggressive stance in Eastern Europe forestalled complete disarmament, but did not drive significant funding to maintain the base.

In 1945, a standby program for government facilities estimated to have an acquisition cost of $1.8 billion was approved. The program planned to maintain the facilities to a degree that mobilization could be attained in 4-6 months and reach full production capacity in 8-12 months. This level of funding was never realized for several reasons. Appropriations and personnel were inadequate. The Corps of Engineers was responsible for conducting maintenance and repair of real property, which was also inadequately funded. Therefore, production equipment and utilities, buildings, structures, roads, and railroad were allowed to fail and deteriorate into states of disrepair at many plants.

Several leaders openly disagreed with the low level of funding and attention to the base after WWII and thought the base should be maintained. The Chairman of the Joint Chiefs of Staff, General George S. Brown said, "Nuclear war remains the least likely course of action for our potential enemies. The capability of industry is critical to the U.S. successfully developing a conventional deterrent…we are experiencing a creeping erosion of the U.S. industrial bases that promises to grow progressively more severe in foreseeable future…industrial base must be capable of sustaining all mobilized U.S. forces (Active and Reserve) in a long war against either the Warsaw Pact or the People's Republic of China."[51] Though U.S. politicians lamented war with China and it was included in strategic planning but the front soon turned to Korea. The below chart illustrates how fast production/procurement was built up over WWII and how quickly it was reduced at the end of the war.[52]

[50] Hammond, 6.
[51] Hammond, 138.
[52] *History of the Ordnance Department in WWII,* Table I (between pages 13 and 14).



The requirements and inventory reporting processes had been so inefficient that in September 1945, the Army was adrift in excess ammunition of all types. In particular, last minute surges in artillery ammunition production provided a significant excess of those rounds. In addition, due to the sudden shut down from full volume production, significant amount of in-progress materiel was on hand and assumed by the Army. Thus, the Army owned components of ammunition rounds in addition to complete rounds. To add to issues, the Army began to retrograde ammunition from overseas theaters or destroyed it in place through detonation, burial or dumping in open water. While the Army knew it had a large stockpile of ammunition, by the time the Korean Conflict started, they were just ending an initial inventory process. This made forecast and planning efforts difficult in the beginning of the Korean Conflict mobilization.

Despite not knowing the full extent of the post-WWII stockpile, the Services determined sufficient ammunition existed and the next war could be fought using the excess stored in the vast depot system. Unfortunately, this plan did not take into account the modernization process or the relative technological state of the excess ammunition. Also, the plan did not consider the potential problems if the next war was long or if there were sustained increases in consumption rates. Finally, because of the reduction in funding, maintenance and inspections did not occur. Far more of the stocks were unserviceable in June 1950 than had ever been expected. [53]

Most ammunition built in WWII supported weapons systems designed in 1940 or 1941. There were some improvements items like the upgraded tank gun or rocket propelled charges, but even those upgrades were designed to defeat weapons in use in 1941. By the Korean

[53] William R. Reeder, "The Korean Ammunition Shortage," unpublished, 1-5. (See all of Reeder for a strong summary of ammunition planning and production in Korea. Reeder was in DA at the time and prepared the monograph as a case study for the Army Comptrollers Course at Syracuse University.); James A. Huston. *The Sinews of War, Army Logistics 1775-1953* (Center for Military History, Washington D.C.: 1966): 630-634.

Conflict, much of the saved ammunition was obsolete. Aircraft were jet powered while their ammunition was designed for propeller speeds; bazooka rounds bounced off German armor and Soviet tanks.[54] Old stocks were unserviceable and the new preferred rounds were in short supply. The ammunition that was still current was often of marginal quality due to a lack of maintenance and surveillance inspections. WWII temporary technical solutions, such as cotton versus silk charge bags and inferior metal in fuzes, had not stood up to the test of long-term storage. Ammunition with maintenance problems that should have been demilitarized in the states was shipped overseas and then destroyed there. During the years between WWII and Korea, several lessons learned in the previous intra-war period were not applied in mobilization planning, management, and sustainment for the ammunition industrial base. Though restarting the base was not as daunting of a task, several of the same challenges and issues were experienced.

Korean Conflict

As Cold War tensions increased between the Soviet Union and the U.S., President Harry Truman committed troops to the Korean peninsula. The Korean War renewed demand for finished ammunition end items. In only five years after WWII, the ammunition base required major rehabilitation before actual production could begin. Fourteen plants remained in an active status, primarily engaged in demilitarization, renovation, and the production of fertilizer. Though the base was warmer than in previous mobilizations, the largest Ordnance challenge in 1950 was to restart the ammunition industrial base they had laid away or used at very low levels of production since 1945. Little to no maintenance had been completed at the inactive plants and maintenance crews had to clean their way onto the lines before they could even start to inspect the machinery. Lines designed for obsolete ammunition had to be reconfigured to new rounds. Modernization had to occur; new employees had to be hired and trained; and production lines had to be proofed out. As a result the average time estimated to reactivate the warm base was around nine months. However, the warm base took over 15-18 months and it took 22 months to get the inactive base into production.

The long lead time for initiating production was just one of many problems needing a solution. Before the GOCO and contractor bases started up, the OD had to acquire funding, compute requirements, break rounds down into component buys, and award contracts. The OD then had to supervise retooling, inspect pilot runs, and approve volume production. The funding issue stymied the start of administrative and production lead-time. Outside of the ammunition base, the DoD had been under efficiency measures since the arrival of Secretary of Defense, Louis Johnson in April 1949. Combat units had been cut and most divisions had two thirds or less of their combat troops and the military faced deeper cuts in logistics. Training was also reduced. Defense was based on nuclear weapons and the focus was on the Soviets in Eastern Europe. In June 1950 the U.S. was unprepared for conflict in Korea and was shocked at the quick advances made in combat theater by the North Koreans.

Despite the unexpected unfolding of events, Congress and the DoD Bureau of the Budget were convinced that Korea would be a short war. In late July 1950, with the U.S. pushed back to the 38th parallel on the Korean peninsula, DoD began preparing the first supplemental estimates to the FY 1951 budget. In late summer as Secretary of Defense, Louis Johnson, defended the

[54] Reeder, 2.

first budget supplemental and U.S. Forces were confined within the Pusan Perimeter; he indicated that they had only asked for extra funding through December 1950 because the war would be over by then. Defense Department planners cut the Ordnance Department's request for ammunition by $2.4 billion to $374 million. Similar cuts happened with the third supplemental, formulated in November - December 1950, when the DoD again expected the war to be over by June 1951. Not until mid-1951 did Congress and DoD realize there were problems with ammunition production and significantly increased ammunition funding.[55] Due to lead time issues, this money did not produce significant quantities of ammunition until 1952.

Part of the problem with obtaining ammunition funding was convincing DoD, and even Army leadership, that all types of rounds needed procurement. The OD had a longer view over the ammunition situation than the Army and DoD leadership. The OD recognized need for increased production across all rounds. To accomplish this, the Chief of Ordnance wanted to create a balanced war reserve in addition to meeting the immediate needs for Soldiers in Korea. Because of his wider vision, he asked for significantly larger amounts of funding than Army or DoD was willing to provide. Army and DoD only saw the amount of WWII excess ammunition. They did not grasp the details of inventory balance by family and weapons type. Not until late 1951 did DoD understand the need for a systemic plan for ammunition production for combat and replenishment, and this was only after most stock in Europe had been reduced below safety levels and rounds transferred to Korea.[56]

The Korean War also impacted the commercial ammunition industry. Army GOCO LAP plants required commercially and government produced components. The problems at the GOCO plants had been partially addressed, but problems were more pronounced in the commercial base. Unlike in the 1930s, U.S. commercial industry was operating at high capacity in 1950. Low levels of ammunition production after WWII had forced producers to convert to commercial consumer goods in order to turn a profit. Any ammunition peculiar plant machinery had been placed aside, removed, or converted. Personnel had been laid off. Without a declaration of war in 1950, or any government call for mobilization, industry was not inclined to turn from profitable commercial production to limited profits in a boom or bust ammunition industry.[57]

The machine tool industry, which had vastly expanded in WWII, collapsed because of significant over capacity in the late 1940s. After WWII, the OD transferred or sold most of the ammunition machinery and tools to commercial entities at well below market value. In the late 1940s the machine tool industry consolidated or converted to other production. The OD collected other machinery to create a National Industrial Plant Reserve. However, as later events revealed, most of this machinery was worn out. The arsenals had cannibalized the good equipment and most of what remained could not maintain production. In effect, the government had dumped supply onto the market and had undercut the very industry most required to restart the ammunition base.[58]

In the 1950s, as the OD began to place orders for machinery or place orders with commercial entities that required new machinery, the machine tool industry over-committed.

[55] Reeder, III-10 to III-15 and V-10.
[56] *Ibid*, II-8 – II-11 and Section III.
[57] Reeder, 7.
[58] *Ibid*, Section III.

They promised significantly more output on shorter timelines than they could deliver, and they did it on fixed price contracts. When President Truman declared war and froze prices, the machine tool industry was in a double bind. The cost of labor had already risen and raw materials soon followed. Because the industry is primarily small business, they had an extremely difficult time producing the documentation required to adjust their sale prices up. An already battered industry began losing money on their Ordnance Department contracts. The difficulties experienced by the machine tool industry had significant impacts on the ability of any sector of the ammunition industry to ramp up to Korean requirements.[59]

A myriad of other problems complicated ammunition production during the Korean Conflict. Problems included a steel strike, the significant increase in rates of fire over the WWII norm, transportation and port difficulties, and the general unpopularity of the effort. In sum, the ammunition base began from a cold start, plants weren't maintained, DoD expected a short war and refused to request the funds required for a longer effort, the stockpile had not been maintained, machine tools were not available, and consumption went up. As a result, it took almost two years for the government and commercial base to achieve full capacity. The Army remained short on artillery, mortars, and hand grenades throughout the Korean Conflict.

Preserving the Base after Korea

At the end of the Korean War the Ordnance Department was determined to maintain a limited active and better maintained inactive plant system. However, once again, budget constraints, Congressional and DoD national priorities, and resumption of Congress' balancing between guns and butter soon led to another period of budgetary decline. In 1953 and 1954, DoD began a drive to privatize all departmental industrial capability. In November 1953, the Secretary of Defense signed DoD Directive 4100.15, "Commercial and Industrial Type Facilities." At about the same time, the Bureau of the Budget published Bulletin 55 which directed DoD not to undertake any commercial activity if items could be purchased from private enterprise. The DoD Directive required all Services to survey their plants to determine which were eligible for lease or sale.[60]

In response to the DoD Directive, the Ordnance Department Directive recommended that the survey not be required for plants manufacturing lethal munitions. They cited the long history of commercial entities producing most military items, but munitions remaining a government operation. Prior to 1955, policy had been "to discourage substantial investment of private capital in … the manufacture of military items having no civilian use…." The Ordnance Department noted that conversion to private ownership

> "[w]ould require additional expense to recreate the industry with the advent of each new production emergency. Business has one principle motive – to make profit. In order for business to make a profit, its capital investment must be made to produce. This would make it necessary to operate such facilities at a capacity which would at least reach the 'break even' point. In order to do so, the facilities would have to be converted to the production of goods which

[59] *Ibid*, 10-11; V-5.

[60] Office of the Chief of Ordnance, "Policies, Recommendations, and Data Relative to Ownership and Operations of Army Arsenals, Plants and Works," 25 January 1955, 3. (Hereafter listed as OCO, Jan 1955) DoD Directive 4100.15 is reproduced at p. 12-13.

could be sold on the open market. The reconversion of such facilities from a peacetime basis to a wartime basis would entail expenses which would be out of proportion to the income which the government could get for such facilities by lease or sale."[61]

Ordnance Department analysis indicated that due to extremely limited commercial application for explosives, propellant, and load and assemble (LAP) of ammunition, there was no strong motivation for commercial operators to build or own their own ammunition related plants. The lack of commercial demand for large-scale explosives production was well known. Of equal importance was the feast or famine nature of government ammunition requirements. The above quote noted that commercial facilities must maintain a minimum sustainment level of production or else ownership must convert to another profit making enterprise. This later point had several aspects. First, while there would be a continuing requirement for training ammunition, new development, and stock rotation, these requirements were miniscule to those for war. Thus, the plants had to have a huge surge capacity. The cost of maintaining that surge capacity would detract from profit margins, yet the underutilized capacity could not be converted to other commercial uses. In addition, commercial industry would have difficulty maintaining a skilled workforce to meet surge requirements, especially in the geographic areas where safety requirements dictated the location of explosive plants. This last point is a factor even at low level production.[62]

Besides the issues of profit motivation, the Chief of Ordnance cited the issue of military readiness. He made a direct connection between civilian enterprise in the opening months of the Korean War, the role of the GOCO plants, and the shortage of ammunition. He noted that even GOCO plants took time to obtain full production, but they were crucial in keeping ammunition flowing in the two years it took to ensure commercial industry reached full volume production. [63]

The Ordnance Department proposed it was in the best interest of the Army and Nation to maintain a primarily government-owned base for ammunition production, but to contract operations to private contractors. In addition to GOCO plants, the Ordnance Department maintained their pre-Korea procurement policy for metal parts and fuzes from commercial sources; but powder, explosive, and loading plants would remain in the organic government owned base. The OD clearly supported following DoD policy of private contracting for vehicles, weapons systems, and other commodities where commercial facilities can produce for both public and private consumption. However, the Department requested a waiver in order to keep ammunition production in GOCO facilities. They believed the shortages and problems of 1950-1952 would be a reminder of the need for a continuing "subsidy" of or investment in the ammunition production base.

Unfortunately, the Korean era ammunition shortages did not remain a priority as we entered the following peacetime period. By the time the Chief of Ordnance had made his recommendations, and implied that ammunition production required a steady level of funding; the Army had already entered the Pentomic Era. The New Look was based on deterrence and the race for nation supremacy would focus on nuclear weapons. In the shift from conventional warfare to nuclear deterrence the Air Force would play a greater role in developing nuclear

[61] *Ibid*, 4, 7-8.
[62] *Ibid*, passim.
[63] OCO, Jan 1955, 7, 9.

delivery systems and strategic defenses like anti ballistic missiles. The Army eventually developed tactical nuclear weapons, such as the Davy Crockett, to ensure a continuing role for the Army. With slogans like "Atomic Guns for Front Line Troops," one could expect the budget for conventional ammunition would drop and it did.[64]

Vietnam

Army budgets improved some in the early 1960s. As the Vietnam War started, spending on the ammunition base mirrored events leading up to and through the initial stages of the Korean War mobilization. Between 1953 and 1965, the Army ammunition industrial base reduced from over 40 to only 26 ammunition plants. Only eight were in operation in January 1965 at extremely low levels of production. The Army had 240 Industrial Plant Equipment (IPE) packages at over 180 commercial firms and only 51 were used in January 1965. The Army Munitions Command (MUCOM) controlled the plants, but the fourteen storage depots were managed by the Army Supply and Maintenance Command.[65]

Like Korea, the Army ammunition base was at a cold start when requirements escalated in the Vietnam War. When troops entered Vietnam in 1965, consumption increased from peacetime rates to full combat rates in an extremely short period. Consumption grew, especially in air delivered items. Expenditure quickly outpaced planned rates and reached record proportions and ammunition shortages rapidly developed. Generally, the same issues that caused shortages in 1950 reappeared in 1965.

In 1965 the Army standard supply rate was based on modifications to the actual consumption rates in WWII and Korea. These rates were usually established as the number of rounds per day per weapon and were published in a Supply Bulletin. Army Pacific had different supply rates than Army Europe. The Air Force had similar standard supply rates based on their historical use factors. These rates were used to develop requirements and were forwarded to the Army or Navy for procurement. Army buying patterns were based on the number of units planned for a particular theater of operations. The Army was also to procure ammunition to fill the War Reserve to an established level.

The Army War Reserve consisted of six months stock for the eight NATO divisions. The remaining divisions were authorized those stocks required to sustain the force from the date of deployment until the date production would meet requirements (D-P Stocks). Despite total years in WWII and nine months in Korea, it was assumed that D-P would be less than six months, so full production was envisioned as meeting theater requirements while rebuilding the War Reserve. In January 1965, ammunition plants were producing at only 7% of the maximum rate required to match the consumption rates published in the Supply Bulletin. Mobilization plans anticipated it would take six months for the active plants to attain full production; 11-14 months

[64] See A.J. Bacevich, The Pentomic Era, National Defense University Press, 1986 for a summary of the Army's reaction to the "Pentomic Era." The slogan "Atomic Guns for Front Line Troops" is taken from a 1960 photograph in File "Davy Crockett Weapons System, M29," History Office, US Army Joint Munitions Command.

[65] Joint Logistics Review Board, "A Summary Assessment with Major Findings and Recommendations," Volume 2, "Ammunition," Washington DC, 1970, 14, 31. Hereafter referred to as "Besson Board."

for the GOCO inactive plants to gain full production; and over two years for producers to meet total requirements.[66]

In January 1965, the War Reserve was significantly less than what was authorized. The figures cited above were authorized in DoD Logistics Guidance for 1966, published in the fall of 1964. However, due to budget limitations, ammunition procurement would not attain the six-month and D-P levels until January 1969. The Army did not buy 100% of the requirement for each year. For FY 1966 the Army purchased only 54% of the Army Pacific requirements. The FY1966 buys were budgeted prior to the outbreak of hostilities when action in Vietnam was not anticipated.[67]

Based on 1964 guidance from the Secretary of Defense, service stockpile levels appeared to be in good shape for 1965; however, this was a false appearance.[68] Hostilities soon revealed significant readiness issues. The first issue was that a large percentage of the stockpile was left over WWII and Korean War stocks. Many of these items were obsolete, unserviceable, or substitute items. For the decade prior to 1965 very little funding had been expended on maintenance of stockpile items. Despite a lack of funding, the Army assumed that all serviceable stocks could be returned to serviceable status. While a funded system may have been able to repair a significant quantity of unserviceable stocks, this would take time; and these were the same stocks stored to maintain the fighting force until the production base could gain full volume.

In addition to serviceability issues, there were challenges associated with technology advancement. Many of the Air Force ammunition items had been produced for WWII and Korean era vintage aircraft. These rounds were unsuitable for high speed jet aircraft, yet they were still listed as authorized substitute items for preferred munitions. However, the asset reporting system masked the technology and serviceability issues. The stockpile was reported to DoD in terms of tonnage, not readiness. Therefore, if the preferred or substitute items were in the stockpile, the tons were reported as on hand and ready for use. Details did not show the percentage of new to old munitions or serviceability by line item.[69] The shortcomings became apparent immediately after the start of large scale hostilities.

Despite the rapid escalation of the conflict in Vietnam and glaring issues of consumption versus production, policy impeded the reactivation of plants and civilian manufacture. Department of Defense policy required Service Secretary and then Defense Secretary approval of funds to reactivate plants. The Major Command Commander could approve renovations and modernization up to $500,000. The Secretary of the Army approved spending for costs between $.5 and $1 million. Projects in excess of $1 million required Secretary of Defense approval. Each request took an average of five weeks for approval.[70] In many cases, contractors would not sign production contracts until the renovation requests were approved. This added more delays resulting in increased production lead times.

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[66] Besson Board, 28, 31.
[67] LTG Joseph Heiser, Jr., *Vietnam Studies, Logistics Support* (Center of Military History, DA: 1974), 119.
[68] Besson Board. See p. 30 for a table of fill rates against objectives for key ammunition items.
[69] Besson Board, 28 and 67-68.
[70] *Ibid*, 102-3.

An even more critical impact on procurement was the decision not to loosen competition rules. In fact, DoD tended to tighten rules on competition until 1968 by continuing to require formal advertisement and bids rather than negotiated contracts. Concerned with the increased costs of ammunition contracts, the Secretary of Defense signed a policy shifting competitive to negotiated contracts in July 1965. He required high level visibility before the approval of noncompetitive contracts over $1 million. Service Secretaries were to approve all contracts between $1 and $10 million, while the Secretary of Defense had to approve contracts in excess of $10 million. This process also took several weeks and further delayed the buildup to full production.[71]

A final obstruction to rapid contracting and activation of the commercial base seemed the most significant. In 1965 the Johnson Administration decided not to declare a full mobilization for the Vietnam effort, which meant that mobilization producers were not obligated to convert their plants to wartime ammunition use. Their contract only required their conversion after a state of emergency and mobilization was declared. Industry did not voluntarily reconvert; they simply were not interested. Their profit motive drove them to continue manufacturing commercial goods, and the government had no recourse without the mobilization order. This failure in mobilization significantly affected metal parts and fuze production.[72]

The inability to attract previously designated mobilization producers coupled with DoD emphasis on competitive contracts created a wave of equipment problems. In 1965 the Army had 240 Industrial Production Equipment (IPE) packages in commercial plants. The producers holding the IPE were generally the expected mobilization producers of certain ammunition components and the Army expected to use noncompetitive contracts with these companies. They expected a slightly higher cost, but a small lead time and equipment investment savings due to pre-siting of the equipment. However, the combination of no mobilization orders and tightening of competitive rules meant that many mobilization producers who did bid, did not win. Contracts were let to unplanned sources. Many of these winners were from the least successful and least profitable firms. If they had been successful, they would not have had the unutilized capacity to convert to ammunition work. In 1968 DoD had 224 private munitions producers. Of this number, only 24 were the same as pre-1965, and only 26 were reactivated producers who had been holding IPE. The remaining 147 were new and often required IPE. The government either bought new plant equipment or paid to have IPE shipped from disinterested mobilization producers. DoD controlled the IPE and this increased lead time as the Services worked to obtain DoD approval to issue the equipment.[73]

The final Vietnam ammunition base issues relate to policy decision on requirements, consumption, and length of the war effort. Each tended to damper the enthusiasm of private producers. After the initial sharp rise of consumption in Vietnam, expenditure rates began to stabilize. However, the Army and DoD changed stockpile and production requirements throughout the war. DoD's key concern was to not build an excess stockpile at the end of the conflict. They finally decided to produce to meet actual expenditure levels. They determined that at the end of the conflict they could use the industrial base to rebuild and balance the war reserve. For producers this translated into a constant change of production requirements and schedules and many periods of slumps. This also meant that the pipeline was often short if there

[71] *Ibid*, 94-95.
[72] *Ibid*, 94, 96; Heiser, 119.
[73] Besson, 102.

was a spike in expenditures after a period of combat lull. This constant shifting of requirements disconcerted producers.[74]

In addition to requirements fluctuations, DoD continued to assume that Vietnam would be a short war. It took 18-24 months for DoD to realize that the short war had gone long. The stockpile and the procurement plan was not designed for this possibility. The Secretary of Defense and Bureau of the Budget continued to plan for a six month war. Not until mid-1967 did they acknowledge that the war might be longer term. Until then each contract, budget and supplemental request was based on the requirements for another six months of combat. Commercial producers, even those patriotic and committed to supporting the Armed Forces, were not willing to convert from profitable commercial work to barely profitable work that would last only six months.[75]

To help alleviate future problems, the Besson Board made a number of recommendations for future management of the ammunition base. While they advocated a mix of private and government plants, they warned:

> "Munitions production is a high-risk venture for private industry owing to the lack of demand for munitions production in peacetime and the uncertainties associated with the length of the war…The facilities and tooling peculiar to munitions manufacturing, coupled with the quantity of equipment required to produce at the desired rates, do not lend themselves in total to alternative commercials use…Profit motivations of private industry does not argue for retention of this equipment in peacetime; hence, the production base tends to evaporate with the cessation of demand."

They also warned that despite their recommendations, military budgets would be reduced after the War. Lack of a strategic DoD level plan, dwindling resources, inter and intra Service disagreements hindered maintaining the ammunition base.[76]

The Besson Board concluded that the ammunition base should be an exception to the privatization policy. They determined that maintaining a warm base and a small stockpile was less expensive and provided more readiness than a large stockpile and a less ready base. The Board suggested the government should own and maintain laid away equipment as it was not within the private, profit motivated culture to do so. The government also had to retain GOCO plants in order to assume safety and space requirements. These plans required a continuing peacetime level of funding for the ammunition base. Their bottom line was: "The Vietnam experience emphasizes the importance of maintaining an adequate production base."[77]

After Vietnam a similar pattern of neglect of the ammunition base continued until the early 1980s when modernization programs were implemented. The government attempted to reduce ammunition expenditures and create efficiencies in a number of ways. The most significant impact between Vietnam and the Gulf War was the creation of the Single Manager for Conventional Ammunition (SMCA) in 1977. The Army was charged with central

[74] Heiser, 109-10, 119-120; Besson Board, 62, 67, 94, 89, 100-01.
[75] Heiser, 120; Besson Board, 69, 107.
[76] Besson Board, 105-106.
[77] *Ibid*, 105-07, 147.

management of conventional ammunition for all Services and three Navy ammunition installations were transferred to the Army.

Analysis of Ammunition Requirements Versus Industrial Capacity Across Wars

WWI

U.S. forces were ready for combat within a year after the declaration of WWI, however, they were mostly equipped with munitions obtained from Allies. Because Great Britain could not sustain explosive requirements, the U.S. industry built its explosives, propellants and loading industry up extensively. Prior to U.S. entry into WWI in 1917, only a few privately owned establishments in the U.S. could undertake ammunition production because requirements had been historically fulfilled by Great Britain and France.[78] Ordnance arsenals were operated at maximum capacity and U.S. industry mobilized to establish munition facilities to produce wartime needs. During WWI, 53 powder, explosive and loading plants operated to meet U.S. and Allies requirements.[79] However, for many ammunition items, the full capacity and operation of the plants was never reached before the signing of the Armistice in 1918.

The American explosives industry expanded to meet the Interallied Ordnance Agreement to augment explosive and propellant production already being produced in England and France. Prior to entry into the war, the U.S had depended on ammonium picrate or explosive "D" as their primary bursting charge for high explosive shells. America quickly expanded its production complex to manufacture amatol and TNT. In 19 months the U.S. produced 632 million pounds of propellant and 375 million pounds of high explosives. Smokeless powder production capacity rose from 1.5 million pounds a month to a projected capacity of over 1 billion pounds per year, bringing the rate of production seven times above peacetime production rates. Explosives manufacturing increased from 660K pounds a month to over 16 million pound capacity by the end of the war.[80]

France and Great Britain accomplished most artillery shell production. When the U.S. entered WWI, stocks on hand accounted for less than a single month's supply based on expenditure rates. Capability to produce a complete round were almost non-existent in the U.S. The U.S. had to develop resources to create metallic parts; shells, fuses, boosters, adapters, as well as design and build new plants for artillery shell loading. The artillery industry and loading plants produced more than 17 million rounds of various filled artillery rounds and 38 million unfilled rounds by 1918.

The U.S. small caliber ammunition industry's ability to meet requirements starting from minimal production rates has been repeated across time. The following chart shows how small caliber ammunition production of machine gun, rifle, pistol, and revolver rounds increased during WWI to almost 4B total rounds of ammunition.[81]

[78] Ordnance Corp History Vol I, 109.
[79] Crowell, 105.
[80] Crowell, 105-110.
[81] *Ibid*, 199.

Date	Rounds
30 Nov 1917	156M
31 Jan 1918	574M
30 Apr 1918	1.3B
31 July 1918	2.3B
30 Sept 1918	2.9B
31 Oct 1918	3.2B
31 Dec 1918	3.94B

Grenade production during WWI prompted one of the greatest challenges for the industry. Initial requirements were set at 68 million live rounds and 3 million training rounds. After initial production and fielding, U.S. Soldiers refused to use defensive grenades because the firing mechanisms were too complicated to use rapidly and Soldiers forgot to release the safety device which then gave the Germans an opportunity to launch the rounds back at them. Production was stopped and all items were reworked to new design specifications. Requirements were adjusted to 44 million rounds to be produced by eight industrial firms. Producers reached 21 million rounds when the Armistice was signed. [82]

After 1918 most of the WWI statistical data and technical knowledge of requirements gained during the war were lost through disuse and failure to study the records before destruction. This, combined with a lack of technical requirement specialists in the workforce, caused the Ordnance Department to miss the opportunity to build and shape requirement calculations during peacetime before WWII mobilization. It wasn't until 1938, that the "Partridge Report" by LTC Clarence E. Partridge and a board of Ordnance officers reported that after analysis of what little data was left over from WWI, "no current battle experience was available," to base WWII requirements.[83] Historian, James Huston, noted the U.S. "had revealed the greatest war-making capacity that the world had ever seen,"[84] during WWI. At the war's end the United States had an Army of over 3.5 million and huge ordnance surpluses.

WWII

The U.S entered World War II (WWII) with virtually a non-existent munitions production base. WWI producers had returned to commercial production and the Army had to build a government owned base from scratch. Ordnance leaders describe the time period as "extremely" difficult as they determined production base capacity while WWII ordnance requirements were in constant fluctuation.[85] Since ordnance requirements were established from troop basis figures which rose and fell every few months as the strategic situation changed, planning and implementing the industrial base size and capacity was a complex task throughout WWII. As soon as one computation of requirements was established it was necessary to incorporate changes and to recalculate computations. A war production board official wrote, "It

[82] *Ibid*, 205-206.
[83] Thomson & Mayo, 49.
[84] "Center of Military History. *Mobilization*. Accessed at http://www.history.army.mil/documents/mobpam.htm, Section 4.
[85] Major N.A. Hamilton, *Army Service Force, Office Chief of Ordnance, History of the Powder and Explosives Section* (Washington, D.C., October 1945) Appendix II, 5.

is literally true, that half the production battle is won when we have decided what we want to produce and when we want it."[86]

Throughout WWII, hindsight has shown that the ammunition industrial base had an abundance of capability due to the conditions of war and fluctuations in requirements. With 112 ammunition plants planned and 86 built, several never operated to full capacity and numerous others were shut down promptly after V-J day, having only operated briefly. In many cases as soon as a plant came into production and completed a few months of initial operation, plant operators were instructed to reduce or curtail production.

Before the outbreak of war in Europe, the Office of the Assistant Secretary of War requested the Chief of Ordnance to provide a detailed outline of ordnance actions in case of war as part of the Protective Mobilization Plan (PMP). The PMP sought to mesh production schedules and the early needs of the Army to bring together the rates of troop and materiel mobilization. In addition, the PMP provided for a small and well-equipped emergency force, called the initial protective force, to provide security during mobilization.

Overall, the 1939 PMP was sound enough to become the permanent basis for mobilization. It established a point of departure, a system for mobilization of the men and equipment already available. Like the industrial plan of the same year, the protective plan stepped back from the M-day assumption and began to see mobilization as a process that should begin well before the U.S. became involved in a war. The plan neglected the important area of construction of adequate troop housing and other facilities, but otherwise it was described as a proposal based on realistic assumptions. The ordnance sections of the PMP estimated a munitions procurement program at a cost of over $6 billion and declared that its computations were up to date for all items under the PMP. Over the next two years the plan was revised, but eventually served as the basis for projecting the needs of war.[87]

During WWII, accurately established requirements were never achieved. The Ordnance Requirements Division faced the challenge of setting requirements based on changing requirements. Each change demanded a revision of total requirement figures and this meant a revision of production schedules. The Ordnance Department felt confident in their computations, however, the ammunition ordnance personnel managing and operating the plants often felt that the planners did not understand the far reaching effects of even minor changes and resulting orders in the overall requirement figures.[88]

To calculate all ordnance requirements Ordnance officials multiplied the quantity of each item of equipment authorized for each type of unit by the number of units in the troop basis. The next step projected those calculations into the future and then further out for additional equipment for replacing losses, filling pipelines, equipping some of the Navy and Marine Corps items, and for supplying Allies with foreign aid. To arrive at net requirements, the quantity of each item already in the stockpile, in storage, transit or possession of the troops was subtracted form the total gross requirement.[89]

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[86] Thomson & Mayo, 45.
[87] Thomson & Mayo, Chapter IV.
[88] *Ibid,* 45.
[89] *Ibid,* 47.

The computation of ammunition requirements was different from other classes of supplies. It ranked high in importance and was sometimes compared to supplying food to the troops. Ammunition was more complex because the rate of consumption was irregular. Ammunition requirements were based on day of supply estimates, which was the average number of rounds that would be expended by each type of weapon per day in the course of planned operations. There were no tables showing the number of rounds to be issued to any tactical unit. The rate for each weapon included a breakdown showing the estimate for each type of shell, high explosive, armor piercing, incendiary, etc; and for each type of fuzes when more than one type could be used on a shell. For training ammunition, specific quantities per man were authorized.[90]

As planners struggled with the best way to predict field requirements, they experimented by linking equipment production schedules to projected ammunition requirements. For example, bombs and ammunition for aircraft called for production of a five-month supply for each bomber, based on aircraft production schedules, estimated number of sorties a month for each plane and the number of bombs dropped and rounds fired per sortie. The computations soon resulted in over production of bombs because all planes did not go immediately from factory to overseas theater or they didn't engage in bombing runs. This resulted in production cuts for bombs in 1943. Then, as air attacks escalated in 1944, many of the cuts had to be restored and production was reinstated.[91]

Adding to the fluctuation included the frequency of equipment changes that occurred 1940-1945. For example, the number of men in just one infantry regiment decreased over the course of the war and its requirements for pistols, trucks and rifles all decreased before 1942 and increased by 1945. The cumulative effect of these changes was enormous and nothing was static.

At the beginning of WWII and two years into it, replacement factors for ammunition were the result of guesswork. No one conclusively knew how long Army equipment would withstand under combat conditions, nor did anyone have accurate notions of how much ammunition an infantry regiment or field artillery battalion would need. Some historians have declared that the day of supply figures used in 1940 and 1941 were defective. The calculations were too high and didn't allow for differences among theaters.[92]

The Ordnance Department came into WWII relying on Frankford Arsenal for small arms ammunition, artillery projectiles, cartridge cases, optical and fire control instruments, gages and pyrotechnics. Picatinny Arsenal focused on artillery ammo, explosions and propellants. While the production capacity was never enough to meet the needs of wartime demand, each manufactured specialized ordnance when expansion was needed. Between 1938 and 1941 Frankford's small caliber yearly capacity increased from 400 million rounds to 630 million rounds by increasing shifts and expanding lines.[93]

The small arms ammunition base is described to be built in waves throughout WWII. Total capacity increased to over 41 billion rounds produced at 12 ammunition plants by 1945.

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[90] *Ibid*, 53.
[91] *Ibid*, 51-52.
[92] Thomson & Mayo, 47-50,
[93] *Ibid*, 188.

Though there was uncertainty at how many small caliber rounds would be needed, the high requirement levels established by the G-4 were questioned by ordnance leaders. The G4 requirements were determined to be correct and in five waves of construction the industry was built up to 12 production plants. By 1941, this seemed to be the correct course of action when small caliber shortages emerged. By 1942, Great Britain's projections encouraged the G-4 to continue plant expansion. By the fourth wave of expansion 80 production lines at three plants were added to bring operating capacity to 20 billion rounds and maximum capacity of 30 billion rounds a year. Small caliber requirements were sharply reduced in the summer of 1942 and 43 production lines were cut during the fourth wave of expansion.[94] Requirements dropped from 59 billion to 23 billion rounds in 1944. In 1945 requirements were dropped to 12.4 billion and continued to reduce throughout the year and then all manufacturing operations at all plants but Frankford Arsenal were shut down. [95]

In 1940 capacity for propellants and explosives in the U.S. was insignificant for supporting the nation's wartime requirements. Production of smokeless powder would have been insufficient to supply more than 1/3 of the requirement and TNT production would have been sufficient for only 13%of requirements for the Army. Requirements began increasing in 1942 and by 1944 the industrial base buildup was significant enough in capacity to meet the maximum requirements.[96] Even as they were building up capacity efficiencies were being discovered and operating plants were capable of producing more than anticipated. At any given point during the war, requirements were adjusted causing plants to be over or under planned utilization.

TNT production tripled after the U.S. discovered reverse nitration methods in practice at a Canadian facility. The U.S. industrial base experimented and adopted the techniques which increased production from 33K pounds a day to 100K pounds. Powder or propellant requirements steadily increased throughout the war and installations were added and expanded to meet the need. In 1943 the plants were operating at maximum capacity before they were ordered to cut back. Then by January 1945 total requirements peaked at 18 million pounds per month.

The industrial base produced over 1 billion rounds of various types of artillery projectiles during WWII which was accomplished at over 60 facilities. As leaders attempted to balance production major exceptions included planning for artillery ammunition, which should have been pushed ahead, versus pulled back.

Adding to the complexity were the requirements calculated rates established by Allies like Great Britain. Many times the Allies overestimated rates of supply and leaders accused them of pulling figures out of the air. These leaders argued that the War Department failed to provide sufficient guidance by determining well in advance how large the Army was eventually to be and what equipment it was to have.

In January 1944 the Ordnance Department was forced to practice short scheduling, with few of these schedules running for more than a month. Changes in types of ammunition required also had effects. Changes were often made suddenly, without advance preparation for

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[94] *Ibid*, 63.
[95] *Ibid*, Chapter IX.
[96] Field Director of Ammunition Plants. *History of the Powder and Explosive Section*. (Vol I, October 1945) Section 4,10-20.

management. Because of the lack of firm, long range forecasts of requirements, it was not possible to concentrate production in the most efficient plants and operate them full time. In late 1943, production load was spread out among many plants to keep them in operation as reserve against unexpected demands. By winter of 1943-1944 many plants were closed. WWII plant capacity grew to support a 10 million man army and by 1945 it was felt that production capacity could be reduced by 40% to support a proposed reserve 4.5 million man army.

The Korean Conflict

When the Korean War broke out, the majority of ammunition production plants were shut down. The Field Service Ammunition Division of Raritan Arsenal in New Jersey was organized to accomplish the peacetime mission of directing supply of ammunition to troops for training and the overall operational supervision of maintenance and preservation of over 7 million tons of ammunition in storage.[97] The Army's munitions production base had declined to 56 ammunition plants, 40 of which were activated to support requirements. The United States had produced surplus stocks of ammunition during World War II, and over 7 million tons of ammunition stock remained in military stockpiles in 1950.[98] There were large stocks of most types of ammunition in the depots and for the first two years of fighting troops were issued WWII ammunition stocks. DoD leaders saw a plentiful stock of ammunition, however, various ordnance district officers saw the need for immediate industrial expansion when the war started. Their primary objective was to reestablish the production base and to reactivate ammunition plants.

Optimism about munitions reserves soon faded, and within a few months leaders were concerned that units in Korea might face shortages. The turning point came in November 1950, when Communist China entered the war. This widened the scope and intensity of the conflict, leading to a surge in demand for most ammunition types. Consumption of ammunition over the next two years far exceeded the rate planners had expected, as outnumbered U.S. and South Korean forces relied heavily on firepower to compensate for their numerical inferiority. For instance, during the Battle of Soyang in mid-May 1951, 21 artillery battalions supporting the X Corps fired 309,958 rounds in seven days, well over a thousand tons of ammunition per day. In late August and early September of the same year, fighting near Inje resulted in the use of more than a million rounds of 105mm and 155mm ammunition in only 15 days.[99]

The supply of ammunition during the Korean Conflict resulted in many ordnance challenges. The Ordnance Department faced a unique wartime situation where concepts of limited war and police action were new to U.S. wartime policy. Preparedness plans had historically been based on premises of total war experience. According to Dr. C.H. Owens, author of *Industrial Mobilization Planning in the Ordnance Department 1946-1950*, the industrial mobilization plan in effect for the Korean Conflict was inadequate.[100]

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[97] Raymond Snodgrass. *History of Ordnance Activities Relating to the Korean Conflict: June 1950-September 1951*. (June 1952) , 43.

[98] *Ibid*, 43-44.

[99] Mark S. Watson, "Ammunition Expenditure in Korea," *Ordnance* (September-October 1952): 254. Also reported in article by CPT David A. Martin, "Artillery Ammunition in the Korean War" accessed at www.almc.army.mil/alog/issues/SepOct98/MS297.htm.

[100] Dr. C. H. Owens. *Industrial Mobilization Planning in the Ordnance Department: 1946-1950.* (March 1956): 47. Copy located in JMC Archives.

Mobilization planning requirements established in years prior to the war by the Chief of Ordnance were forwarded to the Ordnance Ammunition Command (OAC) in March 1948. They were used to determine production facility capacities and equipment requirements necessary to provide items of issue at the rate prescribed to meet issue demands. It became obvious in 1951 that the requirements did not provide a comprehensive picture of all items that were required for mass production and the quantities previously established needed adjustments. In addition, many new items were developed and would need to be integrated into the inventory. Additional requirements were received in January 1952 for all items of ammunition except small arms ammunition and Air Force items. These revised requirements were more realistic and helped establish sound production schedules and provided baselines for determining future rehabilitation activities, planned utilization of surplus plants, and the assignment of workload to meet the existing emergency.

Korean Conflict day of supply rates were defined as the daily average use of the round per gun by a large population of guns operating over a considered time period. The Korean day of supply figures were calculated based on European and Pacific theater usage and experience. Army Field Forces pointed out that these were inaccurate depictions of what was to come during Korea due to the fact that ammunition was rationed throughout WWII and many times when they should have been firing they weren't. The official day of supply was eventually adopted at a much higher rate than WWII figures.[101] Total ammunition authorized amounted to only 45 days of supply in the depots and a basic load and training ammunition in the hands of the units. Until 1952, authorized supply levels stayed basically the same. Then in mid 1952, DA granted an increase of 15 days of supply in ammunition authorizations.[102] As the Far East Command began manning divisions, which were below proper manning levels, the ammunition demand again increased. Budgets for ammunition were constantly reduced from projections as the Army strived to plan for the right amount of production. The Secretary of the Army said, "we are not stockpiling mountains of munitions which might well become obsolete before they are needed, rather we are trying to limit procurement to the quantities of various items which, as far as we can forsee, will actually be needed to sustain our operations in Korea and properly equip our forces with the most modern effective weapons and meet our commitments under the Mutual Defense Assistance Program."[103]

By 1953 the Ordnance Ammunition Command (OAC) had 302 existing production lines; 141 operating and 161 on standby. Twenty plants and Redstone and Ogden Arsenals were producing ammunition Major equipment mechanization advances had been made to increase productivity. Productivity increased by 30% in the first six months of 1952, and OAC planned to gain another 20% of proficiency by 1953. From 1951 to 1953 production increased by 180%. The improved productivity was attributed to modernized equipment and performance improvement that also helped realize full capacity output by using existing operating lines. In

[101] Reeder, II-10.

[102] James Houston. *Guns and Butter, Powder and Rice – U.S. Army Logistics in the Korean War.* (Associated University Press, London: 1989),122.

[103] Committee on Armed Services. *Investigation of the Ammunition Shortages in the Armed Services – Interim Report of the Preparedness Subcommittee No.2 of the Committee on Armed Services United States Senate.* (1953).

1951 the plants produced 50K tons of ammunition and by 1953 production had increased to 165K tons. [104]

	31 Dec 1951	30 Nov 1952	30 June 1953
OAC Production Lines	301	302	302
Lines Operated	94	118	141
Standby Lines	207	184	161
Tons of Ammo Produced	50,000	90,000	165,000

The production lines represented the capacity to reproduce a balanced variety of ammunition items equivalent to 55% of the peak capacity during WWII. Rehabilitation of standby lines began at many plants in 1951. In 1951 over 150 end items were in production but producers utilized many of the metal parts and components that were produced during WWII.[105]

During Korea the small arms base had been reduced from 12 WWII operating installations down to Twin Cities and Lake City, which could be augmented by potential contractor facilities of Winchester, Remington, and Western Cartridge commercial plants if required. In the course of planning for emergency production of small arms ammunition would require additional capability and the Ordnance Corps planned to later reactivate the St. Louis Ordnance Plant to supplement production. Changes in ammunition day of supply figures for small arms increased from 3 to 5 rounds for .30 caliber rifles and from 90 to 100 rounds for .30 caliber machine guns between August 1950 and November 1952 [106]

Minor caliber requirements established during mobilization planning never materialized and the available facilities were planned for utilization to accomplish other production functions such as renovation and demilitarization, assembling gas shells and grenades, and loading tracers and fuses. Most of the minor caliber lines had been built and equipped for interchangeable loading. Requirements as of July 1951 indicated that the use for which they were intended would be limited to the production of 20mm ammunition, as no requirements existed for 40mm ammunition and the sole requirement for 27mm ammunition could be fulfilled by extensive rehabilitation, including the washout and reload of shells currently in stock.[107]

The total 20mm ammunition requirement assigned to the Ordnance Ammunition Center by the Ordnance Small Arms Ammunition Center was scheduled for the Kingsbury Ordnance Plant. Around 10% of the capacity was utilized but requirements forecasted 75% capacity would be required. Ogden Arsenal was assigned the responsibility for reloading and assembling 37mm rounds and began production in December 1950. There were two primary factors which affected the existing surplus capacity in minor caliber ammunition lines. The first was that the lines were originally designed for hand labor and relatively simple production. Automatic loading and assembly equipment efficiency increased 100% since WWII. The second reason was that small caliber requirements anticipated in mobilization planning for which potential production capacity

[104] Office of the Comptroller, Ordnance Ammunition Command. "A Review of the Ordnance Ammunition Center Current Mission, Functions and Responsibilities." 1952.
[105] Ordnance Ammunition Command (OAC) Annual Command History 1951, 9-10. Reeder, 3.
[106] Snodgrass, 57-62.
[107] OAC Annual Command History, 1951, 50-55.

was retained in standby status did not materialize to any great extent. Due to the limited requirement for items originally intended for production, the available facilities were planned for utilization to accomplish other production functions like renovation and demilitarization.[108]

Medium caliber ammunition requirements increased significantly during the Korean Conflict. In 1952 approximately 41% of the industry workload was for medium caliber ammunition. Major caliber shell loading lines were not utilized extensively because of the nature of warfare. The lines were fully utilized for items later classified as critical shortages: 3.5" and 4.5" rockets, and 57mm, 75mm, and 105mm recoilless ammunition.

Requirements and capacity plans indicated that there would be a direct correlation between WWII requirements and Korean requirements for the load, assemble and packing of artillery. Because component requirements such as fuzes, boosters, bursters, primers, percussion elements and detonators were greater for medium caliber ammunition, component production lines increased proportionally.

Hoosier Ordnance Plant, part of Indiana Arsenal was the only bag loading facility reactivated to meet requirements to load propelling charges. Coosa River and New River Ordnance Plants were retained for standby emergency purposes. Chemical loading lines at the Ordnance Assembly Plant and Redstone Arsenal remained in standby to match chemical ammunition capacity utilized during WWII. OAC also established four additional lines at Pine Bluff Arsenal.[109]

For propellant and explosives, arrangements were made for the reevaluation of a large supply of propellant stored since 1945 to fill requirements. New production of Navy rocket propellants were initiated at two plants. A production of a new type of explosive was began at Wabash River Ordnance Works. TNT lines at seven active, standby and industrial reserve works had a total capacity of 210 million pounds per month on 70 production lines. The Ordnance Ammunition Center (OAC) utilized 15 million pounds of this capability with plans to rehabilitate and additional 51M pound per month capacity by the time the war had ended.

The national attention to ammunition shortages during the Korean War caused investigation into reported shortages in theater from the House of Armed Services Committee (HASC) in 1953. Critical ammunition item shortages included the 3.5" rocket ammunition, steel case cartridges, illumination rounds and flares, and all sizes of illuminating shells with double the candlepower. Over the course of the war the 4.2" mortar, 60mm mortar, 81mm mortar, 105mm and 155mm artillery, and hand grenades remained in short supply. After study of the situation the committee reported there was only a small variance between requirements and the ammunition on hand in for each variety. At no time were there critical shortages in theater, and the pipelines were never completely empty. During late 1952 and 1953 the 155mm gun and 8-inch howitzer shells did fall below the day of supply rate but the shortages were kept to the rear depots.

Available supply rates were reported as high as 55 rounds per 105mm howitzer in 1952.[110] At the end of 1952, theater stocks of ammunition remained below maximum authorized

[108] *Ibid,* 52-55
[109] *Ibid,* 53-55.

theater levels but the overall ammunition position was more serious. Expenditures in Korea had exhausted left over WWII stocks. The nature of the phase when reserves were becoming exhausted faster than new production could fill, applied more to ammunition than any other class of supply.

Many contend that Ordnance planners could not plan properly for Korea because of the assumption that the war was expected to be over quickly. Budget and requirements were set for the amount of ammunition used plus the replacement of reserve stocks with no advance planning for a war lasting over 6 months. Continuous expansion of the ammunition program added to the difficulty of stabilizing requirements. Production schedules were subject to constant modification with metal parts availability acting as the principal controlling factor. At no time were installations incapable of meeting schedules but slippages resulted directly from shortages of components. Estimates of productive capability of producers of metal parts, based on contracted rates, and the review of stated production potential by Ordnance districts in numerous cases failed to properly evaluate the impact of factors, which could impact production.[111]

Vietnam

The Vietnam War presented a new dimension to the production and supply of ammunition. As explained during WWII the Army had Allies fighting while we had essentially a window of time to build up the munitions base. In Korea, we relied on leftover WWII stocks to springboard us into the war and reestablish the production base. For Vietnam, reserve stocks were inadequate to provide the time necessary to build up to the point where production equaled consumption (D-P) stocks and the production base wasn't initially responsive to the requirements that developed. When war broke out in Vietnam specific requirements existed for the strategic deployment of Army combat forces to Europe and Pacific theaters. Although forces deployed and the operations they engaged in were small in January 1965, the situation intensified quickly, and the production base had to again reestablish capabilities to meet requirements.

In comparison to the Korean Conflict, the ammunition base operated far fewer production lines to meet requirements. The following chart compares active production lines during Korea in 1954 and Vietnam in 1970.[112]

Production Lines Operating

	Korea	SEA
Small Arms	24	10
LAP	138	86
Propellants	35	31
Explosives	151	75
Metal Parts	20	21
Total Lines	368	223

[110] Committee on Armed Services. *Investigation of the Ammunition Shortages in the Armed Services – Interim Report of the Preparedness Subcommittee No.2 of the Committee on Armed Services United States Senate.* (1953), 15, 3.
[111] Reeder, passim.
[112] Hammond, Table 7.

In January 1965, the U.S. planned to attain industrial capabilities to fight a conventional war to last for 6 months. At the start of Vietnam, 11 GOCO ammunition plants were already activated for the production of peacetime requirements for training and integrating newly developed or improved items into the stockpile. CONUS stocks had few newer munitions, and were mostly surplus items left from the Korean conflict and WWII. Quantatively, inventory appeared to be in a favorable position in 1965. Qualitatively, obsolete ammunition filled the depots.[113] Stockage objectives for Southeast Asia (SEA) forces were predicted to a large extent on availability of assets in CONUS storage.

During initial reactivation of the ammunition industrial base, the changing criteria stemming from force deployments and stock status studies resulted in recurring revision to initial production quantities. The slightest change in requirements further compounded production scheduling.[114] Private industry consisted of 240 base production units assigned to around 180 contractors. The active ammunition base consisted of 12 LAP, 9 explosive and propellant, and 5 metal parts plants. Any single plant may have held diversified missions.

Army requirements determination and stock objective computation was based on authorized ammunition levels for each major command, in days of supply. Day of supply was expressed in rounds per weapon required for one day of operation. Items like grenades and mines were authorized in quantities per unit per day. Specific numbers of rounds authorized per day are contained in Supply Bulletin 38-26. Gross requirements per day were established by multiplying the day of supply for each item by the number of weapons in the hands of troops. The figure multiplied by the number of days support authorized, plus the quantity authorized for training, provided the stockage objective. The figure did not take into account that not all Army units mobilized on D-day and not all mobilized units would constantly be in combat. Several other factors had to be considered to arrive at net requirements.

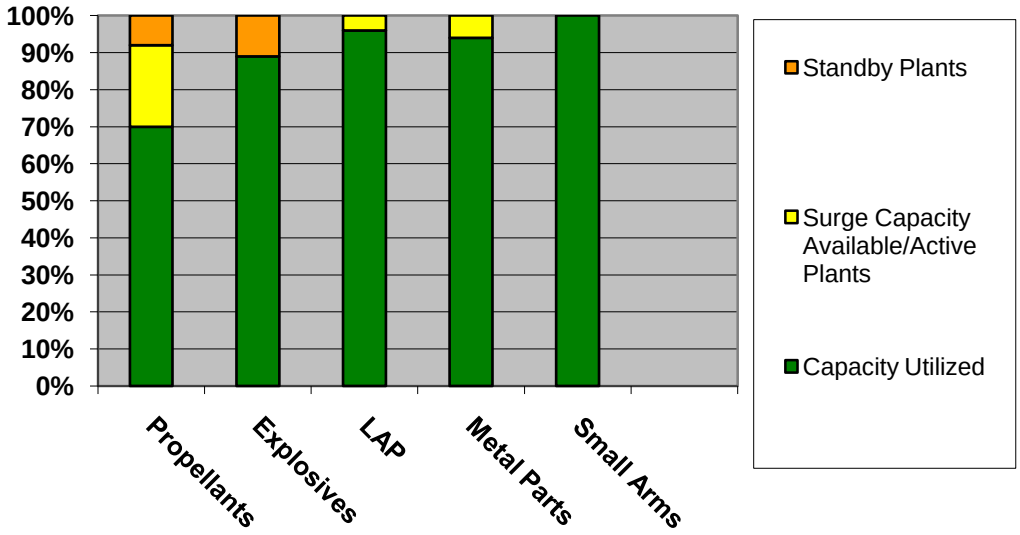
Ammunition requirement determination and levels are discussed in the Besson Board report. In FY1965 logistics guidance specified D-P ammunition support for all active duty divisions, and only initial allowances for high priority reserve divisions. The Army based their inventory objective on six months of NATO oriented divisions and D-P support for the remaining divisions. The inventory objected for the NATO oriented force was computed at the full European theater rate for the period from D to D + 90 for those units in place and those deployed in the first three months of war. Stockage and consumption computation for these forces was reduced to 67% of the supply bulletin rates for the period D + 91 to D + 180. Computations for divisions in the Pacific were made at Pacific theater rates for the first 75 days of war and 67% rate from the 76th to the P day. In conclusion, continual adjustments were made in rates and rate determination techniques, with the ultimate adoption of a dual rate system. This was designed to provide adequate stocks for periods of intense combat but still preclude situation of theater storage facilities when combat was low.[115]

The projected ammunition consumption in Vietnam was also a problem. The Secretary of Defense increased the Army's original calculation of projected consumption, based on Pacific Theater Supply Bulletin Rates, by 50% in formulating the FY66 supplemental budget. Before the start of the conflict, Army assets were critically inadequate. The munitions production base

[113] Besson Board, 27-28.
[114] *Ibid*, 70-74.
[115] Besson Board, 108, 73-74.

(8 active and 16 inactive plants) was producing at a rate of 7% percent of the maximum rate required to match the envisioned consumption rate of basic Army forces. At the onset of Vietnam, the Army's in-house munitions production base consisted of 26 GOCO production facilities managed by the U.S. Army Munitions Command (MUCOM), 24 of which produced conventional munitions. According to RJ Hammond the industrial base operated near capacity throughout the Vietnam Conflict.[116] MUCOM annual histories from this time also illustrated plant capacity and surge. The following chart shows capacity ready for immediate activation for surge requirements, and the percent of standby plants that would require lead time before production could be reinstated.[117]

Ammunition Inudstrial Base Capacity



Load, Assemble and Pack (LAP) and metal parts plants were 100% active and utilized at around 96% capacity. Metal parts production required large investment in production equipment and substantial production lead time. The explosives capacity was activated at 85% with 89% of that capacity used in production. The remaining 15% was Alabama Army Ammunition Plant, that had partial TNT lines available that could be reconstructed in the event of an emergency. Alabama AAP remained in standby status throughout the conflict although it had been scheduled for excess.[118] The propellants plants used 70% of the 92% available, active capacity. Volunteer and Joliet AAPs were operating a maximum capacity of 1 million lbs or more per day and Radford reached its capacity of 330K lbs per day in 1969. The small arms ammunition plant capacity consisted of two plants which operated at 100% capacity. The chart indicates there was little flexibility for surge requirements in the active plants.

Production schedules for small arms ammunition reflected the buildup of Korea during the Vietnam period. Lake City and Twin Cities made up the entire capability for small arms ammunition production. The plants had the added responsibility of making additional items such

[116] Hammond, 9.
[117] U.S. Army Munitions Command, Annual Historical Summaries 1964-1969. Hammond, Table 10.
[118] Hammond, 9.

as the 7.62 mm NATO round and the 5.56 for M16 systems. Lake City was active for a period before Vietnam and mobilized quickly, however, Twin Cities sat idle until its 1966 reactivation making it difficult to recruit a skilled workforce. During Vietnam, Lake City production rose significantly from 600 million to 2.2 billion rounds per year by the end of the war.[119]

As depicted, the ammunition industrial base was reaching peak capacity for production and concern arose about the problem of insufficient manufacturing capacity and also the credibility of the WWII era base infrastructure we were protecting in support of our mobilization planning. Leaders questioned if the Army could keep bringing older, heavily used standby installations into working production capacity in allotted timeframes. When the Vietnam conflict ended and troops were withdrawn, industrial base leaders stressed the need for modernization. In the ammunition sector, programs and projects were planned, however many of the goals were never realized due to funding restraints.

With the exception of intensively high dollar value-high consumption controlled items and air munitions, the matching of production to requirements was not achieved.[120] SEA consumption fluctuated and the goal to match production to requirements was not accomplished. Items like the MK82 500 pound bomb received "total environmental control" meaning all aspects of production, supply to the pipeline and expenditures were controlled. Analysis of production of these items shows that in 1966 month by month production of the items matched expenditure. This was possible because air munitions usage was constrained. Total control was not advocated, but demonstrated that if local commanders on the ground are given flexibility, other constraints outside of consumption must be utilized to maintain essential requirements for a pipeline to the theater and for maintaining reserve requirements to meet worldwide commitments.[121]

In September of 1966 eight items essential to combat operations were close to reaching zero balances. In addition, 21 items would approach zero availability in upcoming months.[122] A Ground Munitions Office was created, however it did not achieve the total control that the Air Munitions Office had achieved with air munitions. The shortage of ground munitions centered on critical items of 5.56mm ball, 60mm HE, 60mm illuminating, 81mm HE, 81mm illuminating, 105 HE, and 4.2" HE cartridges.[123] The impact of the shortages were localized geographically but caused greater use of indirect fire missions, primarily air delivered, and ground commanders were required to modify concept of tactical operations. Ground and air interdiction was reduced and considerable limitations were imposed on the use of night illumination.[124]

In order to fix the critical items shortages, several solutions were applied. Ordnance managers tightened control of transportation and reduced the pipeline in transit time from 120 to 90 days. Beyond the initial planned 6-month period or manufacturing, production was expedited and increased. They also adjusted requirements through establishment of appropriate rates of supply to avoid situations of acute surplus or deficiencies in worldwide stock remedied the shortages. No major operations were curtailed because of the shortages, but expenditures were

[119] *Ibid*, 24-28.
[120] Besson, 99.
[121] *Ibid*, 81-83.
[122] *Ibid* , 55-56.
[123] HE = High Explosive
[124] *Ibid*, 81-83

subject to special control. Numerous factors affected the shortages to include: marginal worldwide stocks, initial readiness of the production base, expenditure rates due to the nature of warfare and insufficient allowance for requirements for surges and escalation of conflict.[125]

Vietnam showed that major fluctuations in combat caused the provisions for a reasonable safety level of stocks above estimated consumption quantities is needed to keep continuous pressure on the pipeline during periods of unforeseen escalation. R.J Hammond claims that the establishment modernization and expansion of a production base in the country must be segregated from the use of requirements that drive and justify its retention. He believed the core base should be kept independent of requirements to realign focus on modernization and retention of the facilities that remained.[126]

The pattern of setting production capability based on requirements from WWII through Vietnam shows that fluctuations, consumption, Army manpower, warfare, policy, budgets and many other factors compound the ability to determine the right size for the ammunition industrial base. By Vietnam almost all available capacity and installations were needed to meet modern requirements. After Vietnam the Single Manager concept was established to centralize the management of all Services conventional ammunition.

A Single Manager For Conventional Ammunition (SMCA) [127]

The Single Manager for Conventional Ammunition (SMCA) was formed in 1977 to consolidate management of ammunition across DoD. The DoD assigned the single manager duties to the Department of the Army, who delegated the execution of the mission to the Army Materiel Command (AMC). AMC further delegated the day to day operations to the Army Armament Command (ARMCOM). ARMCOM completed implementation plans, but the SMCA mission actually went to ARMCOM's successor, Army Armament Materiel Readiness Command (ARRCOM) when that command was activated in FY77. While changes in the delegation of SMCA responsibilities have occurred over the years, the SMCA primary field operating activity has remained at Rock Island as an element of the ammunition management mission of the successor commands to ARRCOM: Army Armament, Munitions and Chemical Command (AMCCOM, FY 83-94); Army Industrial Operations Command (IOC, FY 95-99); Army Operations Support Command (OSC, FY00 to FY02), and Army Field Support Command/Joint Munitions Command (Provisional)(AFSC and JMC, FY02 to FY06) to the Joint Munitions Command in FY06 in conjunction with the newly formed Joint Munitions & Lethality Life Cycle Management Command (JM&L LCMC) in FY07.

The early intent of the Single Manager concept was to eliminate overlap and duplication of production efforts among the Services. In early assignments the Single Manager was given total control over a certain set of homogenous Federal Stock Classes with no deviations or exceptions. Early thought had been to give R&D to the Single Manager, but the Services overruled that idea. At the wholesale level the Single Manager was concerned with net

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[125] *Ibid,* 146.
[126] Hammond, 138.
[127] SMCA section is extracted from a paper George Eaton wrote on the evolution of SMCA. See: George Eaton. *Matching Organization to Expectation: A History of the Single Manager for Conventional Ammunition: 1950 to 2004* (AFSC/JMC History Office, Rock Island: 2005), passim.

requirements, procurement, production, storage, distribution, disposal, transportation, cataloging, inspection, maintenance, and standardization. Mobilization planning was not a Single Manager mission as the Services were still responsible for computing individual requirements.

To help delineate SMCA responsibilities to DoD Directive 5160.65, Subject: Single Manager for Conventional Ammunition, dated April 14, 2004, 'conventional ammunition' is defined as: "A device charged with explosives, propellants, pyrotechnics, or initiating composition for use in connection with defense or offense, including demolitions. Certain ammunition can be used for training, ceremonial, or non-operational purposes." The DoD Directive goes on to specify that conventional ammunition includes small arms, mortar, automatic cannon, artillery and ship gun ammunition; bombs, to include cluster, fuel air explosive, general purpose and incendiary; unguided rockets, projectiles and submunitions; chemical ammunition with various fillers (incendiary, riot control, smoke, toxic agents, burster igniters, peptizers, and thickeners for flame fuel); land mines of any delivery method; demolition materiel; grenades; flares and pyrotechnics; all above items in bulk, combination or separately packaged items; and related containers and packaging materials.

DoDD 5160.65 specifically excludes guided projectiles, rockets, missiles and submunitions; naval mines, torpedoes and depth charges; nuclear ammunition; cartridge and propellant actuated devices; chaff and chaff dispensers; guidance kits; swimmer weapons; explosives ordnance disposal (EOD) tools and equipment; and the containers and packaging for the above items from assignment to SMCA. Some of these excluded items are conventional ammunition.[128]

The current DoD Instruction 5160.68 states that the SMCA is responsible for managing wholesale stocks only, which is defined as: "Conventional ammunition stocks in storage or in transit between the point of production and point of receipt at first retail CONUS activity (such as tidewater port, post, camp or station)." Retail is defined as: "Conventional ammunition stocks in storage or in transit between the point of receipt at first retail (consumer level) CONUS activity and point of consumption."[129]

After WWII the Navy and the Army took different steps as they dismantled the base. While the Army retained a substantial number of GOCOs, the Navy tended to retain Government Owned-Government Operated (GOGO) plants. Both Services had contractual agreements with commercial entities to convert to ammunition production if required. In another difference, while the Army tended to leave equipment in the plants and with contractors, the Navy stored excess equipment at a central location.[130]

The two Services also had different methods of segmenting the forms of production. The Navy tended to have multiple functions at each plant. For example RD&E, production, inspection, storage, and rework were all accomplished at Navy installations. The Army, on the other hand, tended to have production plants and storage depots, which executed different

[128] DoDD 5160.65, Subject: Single Manager for Conventional Ammunition (SMCA), dated April 14, 2004, Enclosure 1, Definitions, 6-7. This definition is essentially unchanged since 1974.

[129] DODI 5160.68, Subject: Single Manager for Conventional Ammunition (SMCA): Responsibilities of the SMCA and the Military Services, dated March 3, 1995, Enclosure 1, Definitions, 4.

[130] Buford Rowland and William Boyd, *U.S. Navy Bureau of Ordnance in World War II* (Bureau of Ordnance, Department of the Navy, U.S. GPO, 1953), 505-09.

functions. Within the production base, the Army maintained ownership of propellant and explosives production while contracting with commercial sources for metal parts and fuzes. The Army then brought all components to Load, Assemble, and Pack GOCO plants for final assembly.[131]

Because of shortages and the need to utilize the best aspects of the active industrial base and plants that were coming on line, the Army and Navy cooperated in the management of conventional ammunition items. This cooperation worked smoothly since the Army Chief of Ordnance and Navy Ordnance Bureau had cooperated in World War II. In the 1930s, primarily via the Army-Navy Munitions Board's procurement planning, the Services had verbally agreed which Service would procure items in an emergency. By 1941 most of these agreements were in writing. For example, Frankford Arsenal made 5-inch projectiles, and Navy funding kept the Arsenal in existence. The Navy considered interservice munitions cooperation as close as working within the Department. The relationship was especially close in the aviation arena. While the Army Air Corps (AAC) went its own way and invested significant funds in developing air-launched torpedoes which the Navy already produced (and which the AAC never used), in most other areas the Services worked together to standardize armaments.[132] Coordination among Services became increasingly more formal. Initially loose management concepts between the Army and Navy buys became tighter as DoD imposed control.

With the publication of DoDD 5160.65 the SMCA became institutionalized. On 14 August 1981, prior to publication of DoDD 5160.65, the Secretary of the Army had issued a SMCA Charter that delegated SMCA responsibilities to the Commanding General, Department of Army Materiel Development & Readiness Command-DARCOM (today DARCOM is the Army Material Command). While many issues drove the issuance of a Charter, the most pressing was continued Congressional questions on who was the one person responsible for the SMCA. The question of a single decision maker vice the committee approach of the Joint Conventional Ammunition Program (JCAP)/CG had been the major determinant in deciding to create the SMCA in 1975. In response to other pressures, the SMCA Charter directed DARCOM to establish a jointly staffed Executive Director for Conventional Ammunition (EDCA) with offices in the Washington DC area. The CG, DARCOM appointed the Deputy Commanding General for Readiness as the EDCA.[133]

In addition, to implementing the EDCA, CG, DARCOM issued a mission order that assigned execution of the SMCA mission of the Secretary of the Army to CG, ARRCOM.[134] The Secretary of the Army decided to place the execution of the SMCA missions at ARRCOM level was made by the Secretary of the Army because it caused the least turbulence and least cost in manpower.[135] While ARRCOM was low in the Army hierarchy, the Secretary of the Army must have assumed that creation of the EDCA would eliminate Government Accounting Office (GAO) concerns about organizational placement. The GAO recommended the SMCA report

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[131] Logistics Management Institute, *Condition and Operation of DoD Ammunition Production Facilities, Phase II, Volume I*, July, 1970, 9-10. This Army arrangement is also described in other documents.

[132] For the discussion on Army-Navy Cooperation in WWII see Rowland & Boyd, 496-504.

[133] Statement from BG Burbules, Deputy Executive Director for Conventional Ammunition, U.S. Army Materiel Development and Readiness Command, during Defense Department Authorization and Oversight Hearings on Department of Defense Authorization of Appropriations for Fiscal Year 1984.

[134] DARCOM Regulation 10-71

[135] Statement from General Wagner during hearings before a Subcommittee of the Committee on Appropriations House of Representatives in the First Session of the Ninety-Sixth Congress.

directly to the Secretary of the Army, so the members of Congress were looking for a SMCA at a high level. BG Burbules, the Deputy EDCA in 1981, explained that CG, ARRCOM "(who was responsible for day to day operations of the SMCA) reports to the EDCA (who was responsible for oversight of the SMCA) who reports to CG, DARCOM who reports to the Secretary of the Army; however, the EDCA did have direct access to the Secretary of the Army if he chose to do so."[136]

Funding was possibly the most significant shortcoming of the SMCA organization as implemented in Phase II and executed in the following years. Implementation plans had called for SMCA funding to be allocated at the DoD level before budgets were broken out to the Services. In addition, DoDI5160.65 directed DoD to "provide for separate identification in the Army budget for the SMCA production base and operations and maintenance requirements."[137]

Another problem was the slow development of an ammunition automation system to assist the SMCA in tracking the DoD wholesale stockpile. SMCA began developing an automation system almost immediately after implementation of the single manager concept in 1977. The SMCA realized they needed faster and more pervasive systems if they were to execute the function of receipt, storage, and issue as well as making recommendations for cross-leveling of excess Service stocks. The Army had expected an ammunition automation system would at least give some visibility of wholesale and retail stocks. Visibility of the retail side was seen as critical to managing procurement. If SMCA could only see wholesale, they would not be able to take retail into consideration while planning buys.

The Defense Standard Ammunition Computer System was slowly brought on line, but later planners attempted to incorporate the functions into the Standard Depot Supply System. This did not work well, and in the early 1990's DoD directed the Joint Ordnance Commander's Group (JOCG) to develop the Ammunition Management Standard System centered on the Navy Conventional Ammunition Integrated Management System.[138] While technology did advance over the years, the failure to completely develop and field a joint ammunition automation system hindered effective SMCA management of the stockpile.[139]

Despite the requirement DoD never properly funded SMCA operations. Each year from 1980 through 1994 concerns arose that the SMCA had to compete for funds within the Army Table of Allowances (TOA) rather than at DoD level between the Services. While the Services remained funded for procurement and major maintenance, the Army was the funding stream for the overhead of SMCA management; storage, surveillance and inventory; development of the automation systems; minor maintenance; and salaries. After 1990 and the end of the Cold War, budgets decreased rapidly while the ammunition stockpile grew. The wholesale stockpile managed by SMCA actually grew due to the return of retail stocks to wholesale inventory and the retrograde of wholesale stocks from Europe and, later, Desert Storm. When the overcrowding

[136] Statement from BG Burbules, Deputy Executive Director for Conventional Ammunition, U.S. Army Materiel Development and Readiness Command, during a hearing before a Subcommittee of the Committee on Appropriations House of Representatives, 1982.

[137] DoDD 5160.65, 17 November 1981, 2.

[138] AMCCOM FY1994 Annual History, 36.

[139] Anecdotally, Mr. John Masengarb, indicated that the final problem with DSACS was that in the early 1990s the project and item managers at AMCCOM refused to cooperate with each other and standardize their management systems. Without common data, the DSACS was unusable and JCAP finally decided to model on the Navy ammunition management system.

of the Army depot system became acute the Services became concerned about reducing the stockpile, because it became more difficult to have their preferred stock issued rapidly.[140] The bottom line was that as Army budgets decreased, the ammunition portion of the budget also grew smaller and the SMCA was unable to maintain the budget levels to adequately maintain the stockpile.

On several occasions, Congress became involved in trying to correct the funding issues. At one point they issued a report on the growing demilitarization requirements and directed minimum annual expenditures to reduce the stockpile. In another instance, Congress directed GAO investigations on the management of excess stocks. One GAO conclusion was that the Services had no interest in directing or funding the disposal of excess as they were not paying the costs of storage. It was, perhaps, the lack of funds that led to reductions in force in the ammunition community in the late 1980s and early 1990s. These reductions led to slower processing times that were noted by Service leaders, but never fixed.[141]

Despite problems and concerns, the SMCA experienced increased effectiveness and efficiency in many areas. Management of all wholesale stocks by one entity improved effectiveness and saved money. The ability to see stocks and suggest that excess be transferred to another Service instead of buying new rounds saved hundreds of millions of dollars. The centralization of buys under Conventional Ammunition Working Capital Fund (CAWCF) reduced competition between the Services and created magnitudes of scale efficiencies. The Integrated Conventional Ammunition Procurement Plan (ICAPP), created in 1981, fostered cooperation between the Services while forging more effective use of the government and commercial production base. The Integrated Conventional Ammunition Maintenance Plan (ICAMP), created in 1983, provided line-by-line analysis of maintenance requirements across the Services and allowed for better forecasting and smoothing of maintenance requirements at the depots. The main intent of creating the SMCA, increased effectiveness and efficiency in the management of conventional ammunition was accomplished.[142]

Throughout the 1980s, the government owned base was revitalized and modernized, but this was due more to a general influx of funding during the Reagan Administration buildups than a DoD or DA level systemic attempt to improve management of the base. The general increase in funding and activity masked the problems of managing the base, stockpile balance, unsteady requirements, and fluctuating production schedules. As soon as the Cold War ended, budgets began to drop and the same issues returned to the forefront.

In the mid 1990s, the GAO published several new reports on DoD's management of ammunition. Reports on small arms ammunition management (1995), artillery shell production (1996), and the ability of the industrial base to meet requirements (1996) were generally favorable. However, each report mentions GAO concerns on management of excess inventory in the wake of post-Cold War drawdowns. In June 1996, after a two year investigation, the GAO published a report on DoD's management of excess ammunition. GAO report GAO/NSIAD-96-129, "Defense Ammunition: Significant Problems Left Unattended Will Get Worse" was critical

[140] EDCA and AMCCOM Annual Reports, 1981-1994.

[141] *Ibid.* See also GAO Report GAO/NSIAD-96-129, "Defense Ammunition: Significant Problems Left Unattended Will get Worse," June, 1996.

[142] The annual reports of SMCA activities, prepared by the EDCA, contain figures on cost avoidance. See the annual reports for specific numbers on cost avoidance and savings.

of DoD's management of excess stocks and re-introduced GAO's continuing concerns about the roles and responsibilities of the SMCA.

The new GAO report noted that each service had significant excess in over 50% of their ammunition items. They also concluded that the Services had no incentive to report items as excess. If the Services allowed SMCA to transfer stock from one Service to another, the losing Service received compensation. However, if stocks were declared excess, SMCA could direct transfer at no cost. In addition, because funding issues had never been resolved, the SMCA carried the entire cost burden of storing wholesale inventory. In effect, the Services had no incentive to declare items as excess because no one penalized them for holding unneeded stocks. Finally, the SMCA still did not have visibility of retail stocks. The services were required to report retail and wholesale assets against requirements but none of the Services, including the Army, were doing so.[143]

In addition to problems with reporting and visibility, budget cuts further reduced SMCA's ability to manage the growing stockpile. Return of stocks from Desert Storm and the post-Cold War Europe drawdown had flooded the depot system that had been reduced in size. Returned stocks had been fragmented in retail operations and required more record keeping and storage space. Funding cuts significantly reduced resources for inventory and surveillance. These concerns naturally resulted from reduced requirements and post-Operation Desert Storm adjustments. But the GAO also noted the Service conflict had muddied the clarity of condition status and readiness reporting. As funds for inventory and surveillance dropped off, more and more items exceeded their required inspection dates. SMCA and Army established procedures had changed the condition code to a non-issueable status, and added a defect code that noted that the items were out of inspection cycle. In 1990, the Services objected to the condition code being changed to a non-issueable condition. The SMCA responded by agreeing to not change the condition code, but left in the defect code. However, most management reports seen by the Services and DoD failed to list deficit codes. It appeared to higher level staff that much of the ammunition was ready for immediate use.[144]

The GAO recommended that that DoD develop incentives to encourage the Services to categorize and report ammunition as excess to requirements, update the list annually, and transfer control of excess to SMCA. GAO also suggested imposing fees on the Services for storage of excess stocks, forcing the use of excess in training, and requiring the Services to include excess disposal costs in their annual budgets. Finally, and consistent with every report the GAO produced on management of conventional ammunition, they recommended ownership transfer of wholesale stocks to the SMCA and full visibility of retail assets.[145]

The PEO Ammunition was first established in July 1987. After 13 months of operation the PEO was disestablished for several reasons. The primary reason was that all the Army's PEOs were for systems while ammunition was a commodity, and no one could define it as a system. In October 2001, the Army opted to reestablish PEO Ammunition along the lines of the Pacific Northwest National Laboratory (PNNL) recommendation, but altered from the super PEO/MSC concept developed by the ammunition working team. PEO Ammunition was created

[143] GAO Report GAO/NSIAD-96-129, "Defense Ammunition: Significant Problems Left Unattended Will get Worse," June, 1996, passim.
[144] GAO Report GAO/NSIAD-96-129, 47-48.
[145] *Ibid.,* 67-68.

as an organization separate from PEO Ground Combat Support Systems (GCSS) and all ammunition PMs moved under PEO Ammunition. In order to address Joint issues, the structure included a PM for Joint Services to integrate requirements from the Services and coordinate with the SMCA. Soon after creating PEO Ammunition, DoD directed a study to reassess the effectiveness of the SMCA and the Executive Director for Conventional Ammunition (EDCA). While ammunition acquisition had been consolidated, the relationship of PEO Ammunition with the rest of DoD remained unclear, especially in light of August 2000 disagreements over transitioning.

In November 2001, the Office of the Undersecretary of Defense (Acquisition, Technology, and Logistics) directed the Joint Ordnance Commanders Group (JOCG) to conduct a special study of the SMCA to update policy and documents. In early 2002, a SMCA Study Group began the process that included a rewrite of DoDD 5160.65 and DoDI 5160.68. It took until January 2004 for both rewrites to be published. Meanwhile, the Army remained focused on life cycle management, the mission of U.S. Army Operations Support Command (OSC) as the primary field operating agency, and the question of whether PEO Ammunition was actually a total consolidation of Army ammunition management.[146] The latter question was easily answered: no. Other Army PMs with munitions interest remained separate from PEO Ammunition. These included PMs Soldier, Smart Munitions, Air Missile Defense, and others. The question on the role of OSC revealed misunderstandings of the SMCA system. Many, inside and outside OSC, seemed to believe OSC was the SMCA, not just the field operating agent. Finally, AMC continued to argue for reintegration of the PM system into AMC for better coordination of acquisition and sustainment.

Many different ideas and concepts were proposed. OSC argued for retention of the SMCA where it was (AMC and EDCA) and creation of an Ammunition Command to ensure consolidation. Others argued that SMCA should move to ASA(ALT) and the PEO Ammunition. In many of these concepts, the EDCA was disestablished and used to man PM Joint Services. Finally, in October 2002, the CG AMC and the ASA(ALT) received a briefing on solutions for Army ammunition management. On 1 November 2002 the ASA(ALT) sent a memo stating his intent to recommend to the Secretary of the Army that the delegation for the SMCA be shifted from the CG AMC to the ASA(ALT) and then redelegated to PEO Ammunition. In January 2003 the Secretary of the Army delegated SMCA responsibility to the ASA(ALT). In April 2003 the ASA(ALT) further delegated that responsibility to PEO Ammunition.[147]

Charter and DoD Regulation Changes

The decision to shift the SMCA to PEO Ammunition was not the end of the story of SMCA transition in the new century. In December 2002, PEO Ammunition requested establishment of a team to update the SMCA Charter. This request came at the same time the JOCG SMCA Study Group was conducting its study. However, the Charter rewrite had to wait for the completion of the DoDD and DoDI. The JOCG members influenced the SMCA Study Group who remained strongly interested in ammunition sustainment and the issue of transition. At the same time, AMC continued to push for reintegration of acquisition and sustainment. AMC presented its ideas in the form of Life Cycle Management Commands (LCMC) that placed

[146] Operations Support Command was the successor to the IOC.

[147] The discussion on contending options is derived from a wide variety of notes, emails, and briefings on file at the JMC History Office as are the 28 Jan 2003 and 16 April 2003 delegation memos.

PMs and sustainers under one commander but kept a reporting chain from the PMs to the Army Acquisition Executive. This was expected to resolve transition and sustainment plans and funding under one decision maker.

The new DoDD 5160.65 was issued in April 2004 and, like its 1995 predecessor, states the general delegations of authority and responsibility for ammunition single management within DoD. It is interesting to note that the Army's Industrial Base Policy 98-1 language is paraphrased when noting the responsibility to stabilize the production base while transferring the government owned base to commercial entities, if feasible while preserving explosives safety. The DoDD also requires the Army to retain the joint EDCA with an Army flag officer or civilian equivalent in command, senior in rank to the SMCA Executor.[148]

In August 2004, DoD approved a new SMCA Charter reflecting the many changes in the ammunition structure. The major change in responsibilities, other than ASA(ALT) and PEO Ammunition designations as SMCA, was in the role of the EDCA. The new Charter seems to increase EDCA responsibility by giving it the new mission of "oversight and assessment of the SMCA Executor in the execution of the mission responsibilities." As before, the EDCA assists in resolving joint issues that can not be resolved by the SMCA, acts as a Service advocate, participates in the JOCG, etc; however, PM Joint Services is specifically designated the initial focal point to resolve Service differences. The Charter also re-established the requirement for an annual report that had been dropped in 1995. In order to maintain linkage to the Army's logistics command, the AMC Deputy Commanding General was again appointed as the EDCA. The US Army Joint Munitions Command (JMC), the successor to the Operations Support Command, was designated the primary field operating agency responsible for ammunition logistics, sustainment, and readiness. The SMCA was required to work through the JMC to execute the SMCA's sustainment mission.[149]

The publication of the DoDD 5160.65, DoDI 5160.68, and the SMCA Charter firmly reaffirmed DoD's intent to manage conventional ammunition via the SMCA system. Strengthening the commitment to transition and joint cooperation reassured the Services that the SMCA would meet their ammunition requirements. The new role of the EDCA, who is still an AMC general officer, assured AMC that sustainment would be considered as fully as acquisition interests. The appointment of the JMC as the logistics provider to SMCA ensured continuity with the established logistics infrastructure. PEO Ammunition's responsibilities for the health of the industrial base paved the way for coordinated acquisition strategy ensuring an efficient base system and most efficient integration of commercial and government sectors of the base. While not mentioned in the DoD publications or the Charter, the establishment of the Joint Munitions & Lethality Life Cycle Management Command (JM&L LCMC) in November 2006 further solidified the cooperation of R&D and logistics to create a corporate Army organization interested in both the best cost for procuring ammunition and the best interests of the ammunition industrial base. The newest rendition of the structure is established.

[148] DoDD 5160.65, Single Manager for Conventional Ammunition, 14 April 2004, 3, 4.
[149] Charter, Single Manager for Conventional Ammunition, dated 16 August 2004, passim.

Studying the Industrial Base through the 1990s

Numerous studies were conducted throughout the 1990s in attempts to justify increased ammunition funding and understanding of the shrinking base. During this time period the industrial base experienced reductions in size. The Soviet threat had diminished and the Army began transforming to meet new demands for shorter regional contingencies. The strategic concept began shifting towards providing power projection in a more unpredictable world. Deterrence, crisis response, forward presence and reconstitution became strategic forerunners. At the same the Army was working under stricter funding constraints with a smaller force.

GAO continued its interest in the ammunition base and in the mid-90s they completed two reports. The first assessed the effectiveness of the Single Manager for Conventional Ammunition. The second assessed DoDs ability to meet peacetime ammunition requirements and replenish the ammunition stockpile following two major regional conflicts.[150] Both reports expressed concern with management of the ammunition base. The GAO noted the decrease in requirements and subsequent decrease in base capabilities. While noting some shortages, GAO determined that the stockpile and production could meet peacetime requirements and replenishment based on current requirements. However, GAO also indicated that if response times were shortened or requirements increased, the base would not be able to replenish and meet peacetime requirements. GAO reported that independent studies had concluded the base was inadequate to meet requirements after two Major Regional Contingencies (MRCs).[151]

In a second report, the GAO questioned DoD's ability to adequately assess their capability to support a war effort and replenish the stocks. They noted the lack of a modern and updated ammunition information management system. The failure to update and share data created several management inefficiencies. Ammunition was shown as available and serviceable despite overdue inspection and maintenance checks. The inability (or reluctance) to share data between the Services resulted in some services consigning ammunition to demilitarization while other Services were short the same items.[152]

Between 1989 and 1998, the war reserve requirements dropped from 2,500 K short tons to 540K short tons to support two Major Theater Wars (MTWs) for a total of a 79% reduction. Training requirements dropped 43% from 135K short tons to 77K short tons. The use of excess war reserve stocks was nearing an end, and the Army needed to pay the full training bill. It is important to clarify that the war reserves were in short supply at this time, as they had been after previous wars. At this time, although the base was seeing major decreases in requirements, costs were rising. Modernization was a major cost driver in the munitions budget. The bottom line was the munitions bill was rising faster than savings from decreases in requirements.[153]

Other recent studies, including the RAND study, studies completed by National Defense University (NDU) in 1996 and 1998, a 1998 GAO report, and a study by the National Academy

[150] GAO, "Ammunition Industrial base: Information on DoD's Assessment of Requirements," GAO/NSIAD-96-133, May 1996 and GAO, "Defense Ammunition: Significant Problems if Left Unattended Will Get Worse," GAO/NSIAD-96-129, June 1996. Both reports were made pursuant to specific requests from Congress.

[151] GAO/NSIAD-96-133, Executive Summary, 1-4. The GAO was probably referring to a Committee for the Common Defense study and a Heritage Foundation study completed in 1994-95.

[152] GAO/NSIAD-96-129, Executive Summary,. 2-8.

[153] "Assessment of the Army's Munitions Strategy." Briefing – DA level. 1998.

of Sciences came to similar conclusions on the state of the munitions base. The base was obsolete, lacked efficiency, and was rapidly shrinking. Each report had different conclusions on how to fix the problems, but their descriptions are similar and low funding levels are a primary focus. A review of these reports is included in the proceeding paragraphs.

The National Defense University (NDU) studies the ammunition base on an annual basis. Their 1996 Munitions Industry Study Report assessed the state of the U. S. munitions industry and future challenges. This study looked at both precision guided munitions (PGMs) and old technology production of bombs, explosives, and propellants. The report documented the current state of the industry noting that the munitions industrial base continues to shrink as production requirements are reduced. Munitions producers would continue to use consolidation, cooperative arrangements, and global partnerships as an industrial survival strategy. They also found that the stockpile did not contain the amount of preferred munitions required for two major regional contingencies (MRCs). They suggested the base could not produce the number of preferred munitions required. NDU suggested that if the U.S. ammunition base continued to shrink, the U.S. might eventually be unable to replenish stock and would be forced to rely on foreign sources for replenishment, an option that several have objected to citing national security as a relevant concern. While remaining the technological world leader, they concluded that low levels of procurement and increased foreign competition had diminished the nation's ability to rapidly produce high-tech weapons. The study group recommended that the munitions program receive multi-year funding to provide stability; service PGM requirements be fully funded; and the government and commercial industries increase collaborative partnerships. Despite their concerns, the report concluded by declaring, "In the final analysis, the munitions industry is troubled but not desperate. There is reason for concern, but no major government intervention is currently required."[154]

In 1998 NDU studied the Munitions Industrial Base (MIB). Focusing on the MIB conventional munitions, precision guided munitions (PGMs), weapons of mass destruction (WMD), and munitions of the future were examined. Each presented unique industrial challenges to the ability to supply the munitions needed to support the National Military Strategy. The issue for conventional munitions was the U.S. ability to replenish our stockpile in time for a second conflict. The study group believed that the conventional MIB is able to provide adequately for the Nation's needs although specific areas require attention. For PGMs, NDU suggested the government monitor the consolidation of the industry to ensure continued American technological superiority and fair competition. For the nuclear component of Weapons of Mass Destruction (WMD), the NDU stressed concerns on whether the Department of Energy would be able to assure the reliability of the warhead stockpile. The study indicated munitions in developmental stages must be pursued to provide Warfighters the best munitions possible. And finally, foreign sales of U.S. munitions and potential offshore purchases of munitions or components must be a key aspect of industrial policy.

In June 1997, the Pacific Northwest National Laboratory (PNNL) published a report recommending complete commercialization of the ammunition base.[155] The AMC, Deputy Chief of Staff for Ammunition commissioned this study as an independent review of the ammunition base. PNNL recommended creating a Program Executive Office (PEO) for

[154] NDU, 1996 abstract.

[155] Pacific Northwest National Laboratory (PNNL) "Recommended Strategy for Configuring and Managing the U.S. Munitions Industrial Base," June 1997, 1.

Ammunition and to use multi-year money for contracting annual production and replenishment. They noted the boom-bust cycle of ammunition procurement made the marketplace too unstable for ammunition producers. PNNL found ammunition companies/producers were either consolidating or leaving to find new markets with higher profit margins. Without profits commercial producers were foregoing capital investment in modernization, maintenance, and R&D. The government had also failed to invest in the base. The ammunition budget was held in low regard and was usually the bill-payer for other programs. PNNL also noted that the Army had more sole source producers and less competition than at any time since before WWII. Despite the poor state of the ammunition base, PNNL believed the Army was capable of producing peacetime and replenishment requirements. However, this was only because requirements were so low, the replenishment time-line was long, and the government base had so much excess capacity. They noted that the industrial base was in near-crisis state and changes to any of a number of variables could render the base incapable of meeting production requirements.[156]

From 1999-2002, the RAND Corporation conducted an extensive review of the ammunition and industrial base. The main focus was on how to best privatize the munitions base (this included ammunition production as well as the manufacturing arsenals). RAND noted that statutory and regulatory policy required the privatization of government owned industry unless the activity is inherently governmental, the private sector will not invest, national security requires government control of employees, or the government can produce the same items at lower cost. Based on their subsequent analysis, RAND concluded that none of the preceding considerations were valid when it came to ammunition production.[157] RAND criticized the Army historical imperative to own the ammunition base and the Army's "attachment" to legacy munitions. At the same time, they noted that DoD buying strategy and the failure to modernize were key elements in driving up the cost of munitions.[158]

RAND provided five different options for dealing with the ammunition plants. They rejected the status quo for a variety of reasons and then analyzed privatization; creation of a Federal Government Corporation; consolidation of equipment and mission onto fewer plants; and recapitalization--the movement of the entire organic base onto one multifunctional installation.[159] Their analysis supported privatization as the best option (although they refrain from making a recommendation). RAND cautioned that privatization could reduce capacity and capability.[160] The results presented by RAND were considered but not accepted by the ammunition community and this has not been the accepted solution to sizing the ammunition industrial base.

In 2002 the National Academy of Sciences (NAS) published "Munitions Manufacturing: A Call for Modernization." Formerly a subordinate to the U.S. Army Tank-Automotive and Armaments Command's (TACOM), Armaments Research, Development, and Engineering Center (ARDEC) at Picatinny, New Jersey commissioned this study. The purpose of the study

[156] PNNL, see Summary,. 1-46.
[157] RAND Corporation, Briefing "PBD 407 Study and the Industrial Base Program Review," 18 Dec 2001, passim.
[158] *Ibid*, Slide 6.
[159] RAND Corporation, "Freedom's Arsenal: A Strategy for Managing the Army's Arsenals and Ammunition Plants (Draft)," March 2002, xix-xxii.
[160] RAND, "PBD 407 Study," slide 7.

was to "evaluate the progress of the Totally Integrated Munitions Enterprise (TIME) and make recommendations for future direction."[161]

Independent and outside studies were not alone in assessing the base, nor were they the first. The Army's ammunition management community came to similar findings. All the reports and studies cited were published in the1990s. However, before that, in the late 1980s and early 1990s, managers of the ammunition base realized that the end of the Cold War would significantly reduce ammunition requirements and that annual Operations and Maintenance, Army (OMA) funding also would decrease. They realized they would have to intensely manage the base to ensure that as funding and requirements shrank, they retained a responsive base able to meet the demands of another large-scale war.

In February 2002, the Association of the United States Army (AUSA) published Landpower Essay No. 02-1, "Ammunition Readiness: Current Problems and Future Implications for Army Transformation." In this paper, author Steven Mullen notes that the Army has been chronically short of ammunition funding for many years. Even when funded at less than the required level, ammunition accounts were raided during the year or served as a bill-payer for other areas. As a result the study concluded that the Army was short of state-of-the-art munitions; training ammunition was under funded in the out years; funding was inadequate for maintenance and modernization efforts; precision munitions were not being procured in sufficient quantities; and most importantly, the ammunition production base was suffering with no surge capacity.[162]

In a briefing titled "Ammunition Support Issues and Challenges," MG Wade H. McManus, Jr., Commander of U.S. Army Operations Support Command, reported problems with the ammunition industrial base in 2002. Stockpile assessments showed critical shortages and a deteriorating stockpile. The stockpile inventory showed 24% of the stockpile as unserviceable and a 25% shortfall of go-to-war munitions. Asset distribution did not support peacetime or Warfighter needs and the demilitarization stockpile totaled 467K tons and was growing. The ability to fill requirements with modern or preferred munitions was limited. The production base capacity was reported to have decreased by 68% over the last 10 years. Single sources for 71 of 302 critical components made a surge capability virtually non-existent. There were no U.S./Canada sources for certain critical components. In addition to these issues, affordability shaped policy and limited modernization and almost no RDT&E was being conducted for legacy systems munitions.

The organic ammunition industrial base in 2001-2002 maintained 26 critical processes for which either no commercial capability existed or was sufficient. The POM bought only 76 of 171 critical items. Peacetime training buys could not sustain the base. Inconsistent procurement and quantity fluctuations resulted in production breaks, lost critical skills, and increased start up

[161]National Academy of Sciences, "Munitions Manufacturing: A Call for Modernization," National Academy Press, Washington, DC, viii. The report is interesting in its call for internet and remote control of production lines as well as the use of modern internet technology to transmit tech data packages, requirements, and quality test results automatically from the plants to a higher headquarters. However, it is apparent that the board did not fully understand the munitions base at the factory level. They never visited any plants and do not cite having received any briefings from the plant operators. All information appears to have come from ARDEC and engineering channels, although they may have received briefings from some civilian defense contractors.

[162] Steven Mullen. "Ammunition Readiness: Current Problems and Future Implications for Army Transformation." AUSA Land Warfare Publication No 02-1, February 2002, p. 1.

costs. There was minimal incentive for capital investment in new technology and the base was underutilized at 26%. After September 11th, 2001, it was expected that homeland defense, Continental Operations (CONOPS), and training surge would place greater demands on the base.[163]

Some of the issues faced were problems with critical end items or components. In 2001, there was only one ammunition links manufacturer for small and med caliber items. There was no source for the M67 grenade body. It was projected that TNT facilities would take $28 million and 18 months to reactivate. Several critical commodities were without domestic sources. Examples include nitroguanidine - essential to the Modular Artillery Charge System (MACS); lead azide used in 85% of munitions; baled cotton linters used in Hydra, 120mm tank rounds, and MACS; red and white phosphorous in smoke munitions; and M234 self destruct fuzes used in artillery, navy gun ammunition and missile programs. As it stood, the base could only affect 10% of go to war shortfalls. The base had marginal capability for preferred and precision munitions but pushes to divest the organic base further increased its fragility.

The reasons why the base was in this particular state have been discussed. Inadequate funding, fluctuations in buys, and lack of long term commitment had not sustained the base or fostered investment. Affordability versus Warfighter needs drove policies. Focus on price versus price combined with readiness had decreased capabilities. While these various studies come to some different conclusions and recommendations, they are consistent in mentioning several key and continuing factors that have negatively impacted the ammunition base since the end of the Cold War and throughout its history. All mention the steep reduction in requirements and even steeper drops in annual funding. They mention the relatively low priority of ammunition in the DoD budget and the repeated use of ammunition dollars as a bill payer for other priorities. The reports discuss the loss of commercial firms in the munitions business, the rising number of sole source suppliers, and the loss of a skilled workforce.

Operation Desert Storm

At the onset of Operation Desert Storm/Desert Shield (ODS) in 1991, only ten ammunition items were considered in short supply. All other ammunition items were at 100 percent of the requirement, on hand or in transit to Southwest Asia (SWA). A strong inventory acquired and maintained over a significant period of years, made ammunition a success story in ODS. No inactive production facilities were brought into operation during the relatively brief conflict. Of the fourteen active ammunition plants thirteen participated in the supplying of munitions during ODS.

In total AMCCOM was responsible for around 181 varieties of conventional ammunition needed in SWA.[164] Planning for maximum rate production during ODS revealed the U.S. production base for mortar fuzes restricted production capability for most mortar ammunition rounds. Prior to initiation of the war in February 1991, a complete sustainability analysis had been conducted laying out the problems facing AMCCOM in terms of sufficiently supplying the forces. According to the study, 106 of 152 items could sustain the fight for at least a year after commencement of actual hostilities and would be supplemented by further production.

[163] MG Wade H. McManus, Jr. "Ammunition Support: Issues and Challenges" (OSC Briefing: ca 2002), Slide 12.
[164] AMCCOM is predecessor command of the Joint Munitions Command (JMC).

AMCCOM found another seven items would reach full rate sustainability within one to three months and an additional 12 items could reach the sustainment level in four to six months. Forty-three items would not be fully sustainable for a whole year. In several instances, items falling into the one year category represented ammunition which had been previously dropped from production due to budget cuts.[165]

AMCCOM created an ammunition base priority listing for recommended strategic facility actions in order to bring more items into full rate sustainability. The highest priority was for increasing domestic base capability of 25mm tungsten penetrators by purchasing special tooling and equipment. Commercial producer, Aerojet was reactivated for the production of 30mm-GAU-8 ammunition and Line 8 at Holston AAP reactivated production of Mine Clearing Line Charges (MICLIC) components. Production of TNT was accelerated at Radford Army Ammunition Plant (RFAAP) as well.

Other ammunition production plants accelerated schedules to meet sustainable rates but this method of meeting the requirements had drawbacks. If an AAP's schedule was compressed so that the production of a twelve month supply was met in a matter of six months, the plant was entirely ahead of production at the end of six months and then needed another six months to a year to handle the long lead time needed to start production again. Only one additional production line had to be opened for the sustainment of ODS which was mentioned above - the 25mm line.

Many of the problems associated with ammunition during Operation Desert Storm were logistical in nature due to the large quantities of ammunition shipped to support ODS. Large movements in transit turned out to be of limited value when President George Bush declared the war over shortly after it had started. It was estimated that soldiers in the field had ammunition available to them at a rate of 180 to 250 percent beyond their actual needs.[166]

Reduction of the Base – Base Realignment and Closure (BRAC)

BASE Realignment and Closure (BRAC) is the process used by the United States Department of Defense (DoD) and Congress to close excess military installations and realign the total asset inventory in order to save money on operations and maintenance. More than 350 installations have been closed in four BRAC rounds: 1989, 1991, 1993 and 1995. The most recent round of BRAC completed in the fall of 2005 and with the commission's recommendations became law in November of 2005.

In 1988 the Secretary of Defense chartered the Commission on Base Realignment and Closure (BRAC) to review military installations within the U.S. for realignment and closure. One way to uncover and release funding was to realign, move, and close Army bases and installations. For the Armament Munitions and Chemical Command (AMCCOM) this meant the closure of idle facilities and plants that had not operated since Vietnam. Reevaluation of the military strategy and decrease in the size of forces drove the decision to reduce Defense infrastructure.

[165] Porter & Lepore, 168-170.
[166] Porter & Lepore, 170.

At the end of the Cold War, the munitions industry was burdened by excess capacity it was unfunded to maintain or modernize. The U.S. Army went through an internal study of the ammunition base and concluded that it was in critical condition and getting worse in 1992. The study questioned whether the base could meet the requirement to sustain U.S. forces in two major regional contingencies. The Army subsequently decreased the number of end-items it was managing from 590 to 246, a 58% reduction designed to concentrate production efforts on those ammunition types truly relevant to future war requirements. A total of 198 production lines were declared excess, and 32,000 pieces of government-owned equipment were removed from the production base. [167]

Subsequent BRAC rounds of 1988, 1991, 1993 and 1995 have contributed to the decrease of the base size and defense expenditure shrank. In these rounds of closure, several production lines and capabilities were transferred to other operating facilities and many plants were taken out of inactive or excessed status and closed down. In 1988 Alabama and Indiana Army Ammunition Plants were closed. From 1991-1993 several of the depots to include Sacramento, Savannah, and Seneca Army Depot were closed and determined to be excess storage. Several realignments also occurred at installations like Letterkenny, Sierra, Tooele and Red River Army Depots. By 2001 the government owned facilities had been reduced to 13 down from 28 in 1991. Contractor facilities were reduced from 163 to 69 in just ten years.[168]

BRAC 2005 presented a unique challenge for the industrial base. It is the first time that operating plants were mandated to close while ongoing manufacturing operations were being conducted. The functions and capabilities located at closing plants are still required to fulfill the wartime requirements. The production equipment will be transferred to existing ammunition plants with excess capacity and the Rock Island Arsenal where production will continue. Capacity and capability for artillery, mortars, missiles, and pyro/demo exists at numerous munitions sites. To reduce redundancy and remove excess from the industrial base, the closure was planned to create centers of excellence, avoid single point failures, and generate efficiencies.

In compliance with BRAC statutes the Joint Munitions Command (JMC) has relocated the Kansas Army Ammunition Plant (AAP) Sensor Fuzed Weapon/Cluster Bomb functions and missile warhead production to McAlester AAP; 155mm ICM artillery and 60mm, 81mm, and 120mm mortar functions to Milan AAP; 105mm HE, 155mm HE, and missile warhead functions to Iowa AAP; and detonators /relays/delays to Crane Army Ammunition Activity. Riverbank AAP relocated artillery cartridge case metal parts lines to Rock Island Arsenal where the lines and facilities will become active in 2012. Lone Star AAP relocated its storage and demilitarization functions to McAlester AAP; relocated the 105mm and 155mm ICM artillery, MLRS artillery, hand grenades, 60mm and 81mm mortars functions to Milan AAP; and relocated mines and detonators/relays/delays functions to Iowa AAP. Mississippi AAP transferred 155mm ICM artillery metal parts capabilities to Rock Island Arsenal. The Red River Munitions Center is in the process of transferring all storage and demilitarization functions to McAlester AAP and relocated the munitions maintenance functions to McAlester AAP and Blue Grass Army Depot. The Joint Munitions Command executed the transfer and realignments carefully to ensure all requirements were filled and any stops in production did not affect wartime requirements or missions. Having completed the successful closure and transfer

[167] MG Wade McManus, Jr. *Ammunition Support Issues and Challenges*. 2002, Briefing.
[168] MG Wade McManus, Jr. *Ammunition Support Issues and Challenges*. 2002, Briefing.

missions, the organic ammunition industrial base decreased to eight production plants, two munitions centers, and three depots.[169]

Sustaining the Industrial Base in the 21st Century

The Army has made strides in transforming into a lighter, more lethal land force. It is no surprise that the current industrial base is the smallest it has been because of underutilization, low funding, better stockpile management and smaller requirements. At the working level of ammunition management, several efforts have been initiated and put in place to better assess readiness, manage stockpiles, and improve plant utilitization; all of which contribute to the health of the industrial base despite its smaller size. At JMC several of the following initiatives have enabled the ammunition community to meet and solve ammunition shortages, readiness, and supply ongoing contingency operations.

The Munitions Readiness Report (MRR)

The Munitions Readiness Report (MRR) system, designed subsequent to the September 2001 terrorist attack, provides major elements of the Army with a common methodology for assessing munitions readiness. The Munitions Readiness Report (MRR) measures ammunition stockpile readiness by assessing the inventory and condition code of ammunition. However, the Army has not always assessed the size of the stockpile in terms of readiness. Two days after the September 11th, 2001 attacks, Commander of the Operations Support Command (OSC), Major General Wade H. McManus, Jr. flew to Washington DC to brief the Chief of Staff of the Army on the readiness of the ammunition stockpile. His news was not good and revealed longstanding issues in the funding and reporting of the stockpile. In the past DA tracked the stockpile based primarily on the number of tons available and location. However, funding gaps since 1990 had reduced the amount of surveillance and maintenance required to keep stocks fully ready for issue. This metric did not accurately reflect the quantity of ammunition that was not in an issueable condition. In 2001, much of the ammunition stockpile was either in poor or unknown condition because funding shortfalls had precluded surveillance inspections and maintenance. Reporting systems assumed that if items were in the stockpile, and not coded for demilitarization, they could be issued. While on hand, many stocks required maintenance and the reporting systems did not reflect that status either.

OSC and its predecessor commands had been warning about the condition of the stockpile for many years, but tightening budgets made it impossible to keep up with slowly deteriorating ammunition. The ammunition base needed time and funding to keep shipping ammunition to the joint forces, and the lack of both presented an immediate problem.[170] Problems stemmed back to the 1980s and then became significantly larger with the return of stocks from SWA after Operations Desert Shield/Desert Storm. Most of the stocks returned from SWA did not receive final inspections. Temporary Desert Storm condition codes, which were slated to be changed to standard codes after the ammunition had been inspected, were still in the database in 2001.

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[169] There are excellent online resources regarding prior BRAC round closures and realignments. See http://www.defenselink.mil/brac/priorbracs.html; http://www.hqda.army.mil/acsim/brac/braco.htm; for present and prior information on BRAC.

[170] AFSC/JMC History Office. *End of Career Oral History Interview, Colonel C. Redding Hobby*. (November 2002), 14-15.

After September 2001, DA decision makers had to contend with potential ammunition shortages. The true impact of Condition Codes E, F, K, and N was that ammunition the DA leadership thought was available could not be used for combat without inspection and maintenance.[171] Resources in the POM could buy about 45% of the shortfall items. Due to the atrophying of the ammunition base in the 1980s and 1990s, surge operations could affect only 10% of the go-to-war shortfalls. To activate laid-away plants would take between seven and thirteen months.[172] Army decision makers made difficult decisions, but they needed to never again be in the position of being unaware of the true status of the ammunition stockpile.

MG McManus returned from that meeting with the idea of creating a munitions reporting system focused on readiness and the Warfighter, not the POM and budget. He wanted a system to show decision makers their options and choices framed in a familiar looking system. OSC immediately began the development of the Munitions Readiness Report (MRR) as part of the Strategic Readiness System (SRS). The MRR calculates ammunition readiness, production, quality, and serviceability for each ammunition item and family and projects readiness for 24 months into the future. Readiness ratings are assigned based on the worst readiness rating among these four areas after using standardized computations. In addition, the system highlights which ammunition items are used by the joint forces. The data in the MRR includes both missiles and conventional ammunition. It measures Army worldwide capability in specific munitions categories, such as small arms, mortars, tank main gun, or cannon artillery. In every category each specific ammunition item is tracked. For example, in the small arms category, the MRR tracks 5.56mm, 7.52mm, .50 caliber, etc. in every configuration. Newer items of munitions, not yet transitioned to National Inventory Control Point (NICP) management, are included as well. The data included is the result of a collaboration involving input from many agencies.

From 2002 to 2004, JMC updated this data quarterly, with interim flasher reports whenever significant events impacted readiness. In 2005 the readiness team began a monthly update to the database. The MRR ratings now projected out to predict the ratings in six, twelve, eighteen, and twenty-four month projections using statistical production models based on usage. The online database also provided the ability to "drill down" to individual munitions categories to explore the key issues, components, or pieces driving readiness.[173]

In 2006 JMC's Readiness Directorate refined the depiction of the ammunition status. Reporting of the MRR provided a single ammunition common operating picture (COP) or one voice to decision makers. The MRR was shown differently within the Balcony Brief, a briefing to the Vice Chief of Staff of the Army at HQDA. The view referred to as the Single Ammunition Common Operating Picture (COP) provided a monthly worldwide munitions status and have a predictive capability forecast out to 24 months for the Balcony Brief. The data

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[171] Condition Codes represent the availability of stock for issue, not just on hand. CC A, B, and C can be issued. However, CCs E and F need light or extensive maintenance; CC J is suspended either due to a known problem or simply because two or more scheduled inspections have been missed; CC K means that items have been returned but never inspected to determine serviceability (many Desert Storm returns remain in this category); and CC N means items can be issued for emergency combat use only. See FM 4-30.13 Ammunition Handbook: Techniques, Tactics and Procedures for Munitions Handlers.

[172] Op cit, slides 4 and 16.

[173] OSC History Office, *Annual Command History, FY2002*: 4, 262. See also Jamieson, Edward, OSC briefing, "Army Munitions Readiness," 9 August 2002.

provided is quantifiable and validated by repeatable methodologies. The MRR Ammunition COP allows DA G3/5/7 override capability to make qualitative judgments outside the system. Once qualitative judgments are made, JM&L-LCMC is notified and the information is passed onto Program Managers and Commodity Teams. The MRR is then reconstructed as the Balcony Brief by the Readiness Directorate where acquisition, technical, production and logistic solutions are applied to items that are not in a green or issueable stated.[174]

Finally, working with the Joint Ordnance Commanders Group (JOCG), progress was made towards creation of a joint munitions reporting capability. The Navy linked their Ordnance Information System (OIS) Naval Forces Readiness Operations Assessment (NFORA) system to the National Level Ammunition Capability (NLAC) system. NLAC is a joint munitions asset reporting platform. NFORA is a web-based system utilizing color-coded readiness ratings similar to the Army MRR. The Marine Corps linked their Ammunition Readiness System (ARS) to NLAC, and is having JMC track their readiness in the MRR. The ARS was designed using the Army MRR as a model and has a very similar look and feel. In addition to these new links, NLAC has duplicated the Army MRR function without a link and that capability was being beta tested. The MRR continues to transform and merge with all Services in 2007.

During OEF/OIF the system highlighted and prioritized funding for specific ammunition pacing items and other shortages. The ability to project ratings into the future assisted JMC in funding maintenance programs to upgrade on-hand stocks into issuable condition codes. In addition, visibility from the MRR allowed more timely decisions on shifting of stock from one theater to another.

In 2009, MRR improvements changed the way JMC 'stacked' assets against requirements. Working closely with DA, a way to better reflect real allocation priorities was established. Prior to this method change, war reserve requirements were considered first, and in total, held priority over training requirements. With the change, a critical level of war reserve requirements are considered first, then training requirements are considered, and finally, the balance of war reserve requirements are applied. Critical war reserve levels are determined by DA.

How does the MRR impact the industrial base? Being able to accurately report inventory and calculate what we have on hand or in production, to provide ammunition for war, training, or emergencies; helps regulate requirements. The look at each component and end item shows where focus needs to be directed within the commercial or government base. As we have learned from previous wars, forecasting requirements and determining what needs to be produced is a challenge that has directly impacted the size of the base. Over and underestimation have caused large build ups and reductions in the base. Though situations may arise outside of requirements/readiness control, it is reasonable to assume that the tool will continue to be useful at all levels of Army and Joint Services to assist in industrial base decisions.

Industrial Base Assessment Tool (IBAT)

In addition to assessing the readiness of the stockpile, the JMC worked with the Ammunition Enterprise partners and contractor, Decision Sciences Inc. to develop the Industrial

[174] Joint Munitions Command, "MRR and Balcony Brief" Briefing. 28 March 2006: Slide 1-4.

Base Assessment Tool (IBAT). The SMCA Industrial Base Assessment Team (IBAT) is an initiative to automate the Ammunition Production Base Plan to facilitate industrial base preparedness planning in acquisitions. The SMCA IBAT is a web-based data system that documents the production capabilities, capacities, production schedules, deficiencies, and industrial base metrics of the SMCA ammunition supply chain to assist in optimizing acquisition decision making that affects the preparedness of the National Technical Industrial Base (NTIB). The data system also provides "what-if" scenario generation and ammunition maps to identify potential supply chain choke points. The data system contains over 500 end items and over 700 components and will be a viable asset to assessing the industrial base.

The IBAT is used to help the command perform industrial preparedness planning for critical ammunition end items. The IBAT assists the ammunition enterprise in planning production schedules for peacetime and emergency surge demands. Instead of focusing on replenishment, leaders will be able to focus on capabilities-based planning and support current operations. The IBAT contains real time data on capacities, workforce skills, technologies, stockpile levels, deliveries versus schedules, customer satisfaction, environmental data, financial viability of producers, POM item costs, and more. It also contains analytical tools that predict base responsiveness against any set of requirements. While still in developmental phases the tool has already proved to be useful in providing real time data. The IBAT has gone from a once every two year assessment to providing real time data to the entire ammunition community. It also contains simulation tools to calculate pacing operations and has the ability to respond to various conflict scenarios.[175]

Armament Retooling and Manufacturing Support (ARMS)

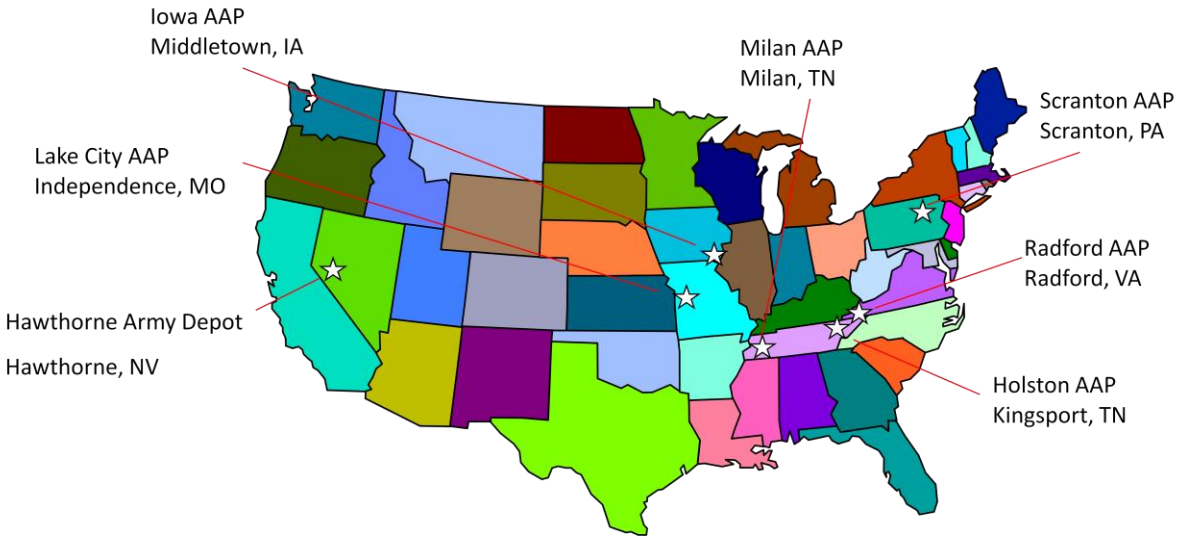
One issue that continuously hampers the sustainment of industrial installations is the inability to maintain a profit during peacetime. Historically, facilities were emptied and completely inactivated and therefore not maintained. The Armament Retooling and Manufacturing Support (ARMS) Program lowered the cost of ownership of Army government owned-contractor operated (GOCO) ammunition plants while creating jobs and retaining critical skills and machinery in the industrial base. The ARMS program provides opportunity to use underutilized portions of ammunition plants. The ARMS Program is designed to encourage commercial use of the Army`s inactive ammunition plants through many incentives for businesses willing to locate to a government ammunition production facility. The ARMS Program was established by an Act of Congress in FY93 as P.L. 102-484, dated 23 October 1992, now codified as 10 USC 4551-4555, dated 30 October 2000. In FY01, Congress extended the concept to the manufacturing arsenals by creating the Arsenal Program Support Initiative (ASPI). ARMS meets the intent of Congress with verified lower cost of production, retention of critical technical skills, significant contractor-funded modernization, and the reduction or elimination of the annual cost of facilities maintenance. The program is successful and maintenance costs of three ARMS facilities have been reduced to zero due to the benefits obtained by tenant use.

In October 2003, the ARMS Program won the 2003 CoreNet Global Innovators Award recognizing new entrants in the corporate real estate industry that develop and apply innovative

[175] Al Beuster, "The Single Manager for Conventional Ammunition Industrial base Assessment Tool," *Army AL&T* (July-August 2004), 64; PEO Ammunition. Ammunition Industrial Base Management Briefing.

ideas and practices and make good use of leading-edge technologies and practices. JMC's ARMS Team was one of five recipients of the 2003 Global Innovator's Award. This award was given by CoreNet Global who recognizes excellence in the strategic management of corporate real estate. CoreNet Global described the ARMS Program as "an innovative program designed to treat its ammunition production facilities and surrounding real estate as assets, while letting the commercial marketplace help reduce the cost of Army operations and production." The other four recipients were Ford, Toyota, Sprint, and the Greater Fort Bend Economic Development Council.

In FY09, ARMS reported that total savings to the Government ($407 million) exceeded ARMS investments and incentives ($274M). Economic impact reached $6.9 billion in output since the program's inception. Currently ARMS programs are at the following JMC installations.



ARMS continues to bring new life to industrial sites to enhance the readiness of the base, generate revenue to maintain infrastructure, make capital improvements, lower the unit cost of production, continue environmental remediation and sustain local economies. By reducing the government's cost of ownership of these installations, we are improving their future vitality.

An Ammunition Enterprise

The Program Executive Office for Ammunition (PEO Ammunition) was reformed in October 2001. The PEO was designated the Single Manager for Conventional Ammunition (SMCA) and has life-cycle responsibility for the acquisition of conventional ammunition. With PEO Ammunition designated the SMCA Executor, it has primary responsibility for the acquisition of all Services' transitioned conventional ammunition. Together with the Joint Munitions Command (JMC) as the SMCA Field Operating Agency (FOA) executing the logistics and sustainment roles, PEO Ammunition retains and executes life cycle responsibility for conventional ammunition for all Services.

Through the establishment of the PEO, ammunition management was unified and integrated under one single chain of command. PEO Ammunition developed unified munitions

acquisition strategies across families and is working towards integrating requirements across training, war reserve, and modernization. The PEO is bringing a disciplined acquisition management approach to managing ammunition as a family, by family. The organization manages the family of ammunition as a major acquisition program making smart acquisition decisions for ammunition as a whole and not only as an individual program. PEO Ammunition optimizes key business processes through the application of Lean/Six Sigma tools and methodology.

On 2 August 2004, the AMC Commander and the Assistant Secretary of the Army for Acquisition, Logistics and Technology established a Life Cycle Management (LCM) initiative through a Memorandum of Agreement (MOA). The objective of the LCM initiative is to get products to the soldier faster, make good products even better, minimize life cycle cost and enhance the synergy and effectiveness of the Army Acquisition, Logistics and Technology communities. From this, the Joint Munitions & Lethality Life Cycle Management Command (JM&L LCMC) was formed; aligning the JMC with PEO Ammunition and ARDEC. Implementation plans for the LCMC relationships, processes and reporting chains were further carried out between FY2005 and FY2007.

PEO Ammunition, JMC and the Armament Research, Development and Engineering Center (ARDEC) form the Joint Munitions & Lethality Life Cycle Management Command (JM&L-LCMC) to integrate supply chain management of the ammunition, to include the production base. The collective mission is to execute integrated life cycle management while creating battle space dominance for the warfighter with superior munitions. This mission will be achieved through development and procurement of conventional and leap ahead munitions which increase combat power to Warfighters. These organizations share the goals to put precision guided munitions and smart weapons into the hands of the warfighter, and to improve and sustain conventional munitions.

Supply of Ammunition to the Global War On Terrorism (GWOT)

At the end of the FY09, the JM&L LCMC reported supporting OEF/OIF with approximately 279,000 short tons of ammunition equaling ~ 25,400 containers. The readiness status had improved from 30 of 42 ammunition families being in a red/black (unacceptable) status in 2001 to 44 of 44 families now rated as green or amber in 2009. As an enterprise, several success stores have unfolded in support of supplying Warfighters with ammunition. The enterprise responded to the increase in small arms training requirements and operational requirements by awarding urgent procurements, accelerating production, establishing a second producer and modernized the industrial base to be more efficient and effective. The command responded to increased demand for countermeasure flares by accelerating production, increasing capacity, monitoring transportation, and maintaining daily communications with the field. The LCMC established a theater reclamation facility in Kuwait to inspect, repack, and reissue ammunition within theater. The operation supported Army Reset, including Special Forces and Marines and allowed more ammunition to reenter the stockpile at a faster rate for issue. The following paragraphs show a variety of the initiatives taken to ensure ammunition requirements were met during this War.

Small Caliber Ammunition

The JM&L LCMC increased production in areas needed despite reduced infrastructure of the base and reports several success stories. In 2001, Lake City AAP (LCAAP) was the sole government-owned contractor-operated small caliber ammunition production capability in the industrial base. The operating contractor, Alliant Techsystems, ATK met the challenges of completing stringent requirements in response to urgent wartime demands. After September 11th, 2001, requirements surged to support training and OEF. As troops began their deployment to Southwest Asia (SWA) and other areas around the world, the requirement for additional, immediate use small caliber ammunition increased tremendously. Lake City was awarded $19.2 million in Defense Emergency Relief Funds (DERF) to increase Total Plant Volume (TPV) capacity from 800 million to 1.2 billion rounds a year for contract life; and to accelerate delivery, provide additional plant capacity for links, and other quality improvements. LCAAP shipped over 58 million cartridges in direct support of Operation Iraqi Freedom (OIF) in the early weeks and months of the conflict.

In FY03 LCAAP continued its ramp-up of small caliber ammunition for all the military services and produced over 600 million rounds. Because JMC still encountered stockpile shortages for items critical to combat operations, several second source or urgent buys were completed in FY04. In addition to procuring 1.2 billion rounds from LCAAP valued at $354 million, JMC also conducted ten urgency procurements to buy 312 million small caliber ammunition rounds from suppliers around the globe. In order to address the shortfall, JMC also invested $28.8 million into LCAAP modernization to further improve and increase its capabilities.

By FY05, JMC managed the production and delivery schedule for 1.34 billion rounds of ammunition produced by LCAAP, valued at over $487 million. JMC also awarded contracts were awarded for production of 300 million rounds of small caliber ammunition to General Dynamics Ordnance Tactical Systems (GDOTS) as its second source supplier. Urgent buy contracts were awarded to Israeli Military Industries for 70 million rounds of 5.56mm M855 ball and 31.4 million rounds of 7.62mm blank; and to Olin Winchester for 70 million rounds of 5.56mm M855 Ball. Further actions to mitigate the urgency, included the procurement of 79 million rounds of 5.56mm and 41 million rounds of 7.62mm from the United Kingdom. In total, 215 million rounds were procured as urgent buys in FY05. Other methods of increasing the small caliber ammunition stockpile included the execution of maintenance programs for .50 caliber to recapture 10 million rounds of A576 (4API/1API Tracer w/M9 Link) from March 2005 through Jan 2007 at Blue Grass Army Depot. Rounds were acquired from the USAF via cross-leveling and from the Army demilitarization account. This resulted in the successful recovery of 2.8 million rounds by the end of September 2005. Aggressive acquisition strategies kept pace with urgent requirements. In FY08 small caliber production rose to 1.4 billion rounds and capacity was being increased to 1.6 billion through modernization projects.

TNT

In FY03 significant demand for TNT, used primarily in support of USAF general purpose (GP) bombs, depleted existing inventories of TNT at an unanticipated rate. This required the development of an acquisition strategy for this critical item. History showed that Radford and Holston Army Ammunition Plants had been filling TNT requirements from the SMCA stockpile

for a number of years. After producing more than 595 million pounds of TNT between 1968 and 1974 and 1983 and 1986, facilities were placed in standby status. TNT production was halted at Radford in 1986 because of the amount of TNT held in storage and because the process was producing red-water.[176] As the TNT stockpile depleted, the user community became increasingly concerned about the ability to meet future requirements, especially after September 2001 when demand significantly increased.

Extensive market research conducted in FY02 identified the lack of a viable and cost-effective domestic production capability for the material. Working with representatives from Office of Secretary of Defense, PEO Ammunition, PM Arms, Executive Director for Conventional Ammunition, AMC, the Air Force, Ogden Air Logistics Center, Tank-Automotive Command-Armament Research Development and Engineering Center, PM Demil, and Defense Ammunition Center, a three-tiered acquisition approach was structured to facilitate the supply of TNT. Subsequent to release of a draft solicitation, a best value request for proposal (RFP), incorporating formal source selection criteria and evaluation of multi-year versus multiple year pricing, was issued in February 2003. The RFP's evaluation criteria mirrored what the Government had previously identified as being the primary focus of this effort: the establishment and operation of a flexible bulk explosive manufacturing capability within the National Technical and Industrial Base (NTIB) to become the Government's exclusive source of supply for TNT within 36 months after contract award.[177]

ATK was awarded a multi-year contract to produce TNT in 2003. The contract included buying OCONUS TNT and reclaimed TNT for the first two years. In 2005, ATK began producing TNT at Radford, requiring thorough process proofing and QA system analysis. During the interim period after award, TNT derived from reclamation activities originating from excess inventory/material would be desired, with supply from OCONUS sources being the final and least attractive alternative. During the first two years of the contract, Alliant Ammunition and Powder Company (AAPC) (ATK) reclaimed TNT from 750 lb bombs and purchased TNT from Poland. However, relying on offshore producers is problematic for a number of reasons, plant officials say. 'Theoretically, you and whoever you are fighting with could be buying material from the same place,' said Ron Rossi, a government civilian executive assistant at the plant.[178]

Countermeasure Flares

The enterprise also supplied OEF/OIF with critical aircraft countermeasure flares for aircrew and aircraft survival. The M211, M212, M206 and XM216 Air Countermeasure Flares are part of a family of advanced Infrared (IR) decoy flares designed for use by Army helicopters and fixed wing aircraft to meet advanced threats. Three of the flares (M206, M211 and M212) are used in conjunction with one another to form the Advanced Infrared Countermeasure Munitions Flares (AIRCMM) solution. The SMCA's countermeasure (CM) flare team placed significant management efforts into the production and delivery of M206, M211, M212, MJU-7,

[176] Angela Manese-Lee. "Explosive industry: By the end of the year, the Radford Army Ammunition Plant will become the only site in the United States that produces TNT." *Roanoke Times*, 28 May 2006.
[177] AFSC/JMC History Office. *FY2003 AFSC/JMC Annual History* (March 2004): 12.
[178] Angela Manese-Lee. "Explosive industry: By the end of the year, the Radford Army Ammunition Plant will become the only site in the United States that produces TNT." *Roanoke Times*, 28 May 2006.

and MJU-10 countermeasure flares when the items were in short supply. The CM Flare team established procedures and processes that allowed contractors to meet vital product delivery schedules to the Air Force and Army in support of urgent requirements. Through aggressive management, sufficient stocks were built allowing assets to be placed in depot rather than being shipped directly from the contractor to theater via air transportation. This turnaround took place in October 2007 and has continued to the present.

Grenades

In support of OEF/OIF, the LCMC adjusted acquisition strategies for grenades. The grenades program includes lethal grenades such as the M67 Fragmentation Hand Grenade and the AN-M14 Incendiary Grenade as well as multiple color smoke grenades (M18), screening smoke grenades (M83), and vehicle launched smoke grenades (M90, M76, and M82). The M67 systems contract established an additional CONUS source for the C70 detonator where only a single overseas (OCONUS) source had existed before. At the request of the Army, PM CCS expedited the incorporation of the confidence clip into new production as well as the existing inventory of lethal hand grenades to make the grenade safer for Soldiers to use.

Vehicle Protection Systems

The JM&L LCMC also provided logistical and sustainment support for the various CLASS V vehicle protection systems to include Bradley I/II, Stryker I/II, Abrams I/II, and Assault Breacher Vehicle. The team supported production management planning for the Bradley, Abrams, and Stryker tiles which were in development or had ongoing contract deliveries. Key areas of emphasis included coordinating NSN/DODIC assignment and deployment planning for BRAT II tiles as well as preproduction planning, materiel release documentation, and storage site assignment for Stryker II.

Today's Industrial Base

Many of the Army's ammunition production facilities are still owned by the government and operated by contractors, with the exception of two that are government-owned and operated: Crane Army Ammunition Activity and McAlester Army Ammunition Plant. Due to 2005 BRAC actions Kansas AAP, Lone Star AAP, Mississippi AAP, Riverbank AAP, Red River Munitions Center (complete in 2011), the current list of active JMC production and storage sites that make up the U.S. Army ammunition industrial base is as follows:

Anniston Munitions Center, Anniston, Alabama
Blue Grass Army Depot, Richmond, Kentucky
Crane Army Ammunition Activity, Crane, Indiana
Hawthorne Army Depot, Hawthorne, Nevada
Holston Army Ammunition Plant, Kingsport, Tennessee
Iowa Army Ammunition Plant, Middletown, Iowa.
Lake City Army Ammunition Plant, Independence, Missouri
Letterkenny Munitions Center, Chambersburg, Pennsylvania
Lone Star Army Ammunition Plant, Texarkana, Texas
McAlester Army Ammunition Plant, McAlester, Oklahoma
Milan Army Ammunition Plant, Milan, Tennessee
Radford Army Ammunition Plant, Radford, Virginia
Scranton Army Ammunition Plant, Scranton, Pennsylvania

Tooele Army Depot, Tooele, Utah

Red River Munitions Center, Texarkana, Texas – Scheduled to close in 2011
Quad City Cartridge Case Facility, Rock Island Arsenal, IL – Scheduled to open in 2012
Defense Ammunition Center, McAlester, OK – Ammunition Knowledge and Logistics Support mission

An economically configured ammunition production base capable of supporting war reserve, training, and emergency requirements is essential. The Army is committed to improving the utilization and efficiency of the Defense Industrial Base. The FY07 PB funding supported production base modernization improvements at Radford, Holston, and Lake City Army Ammunition Plants (AAPs). Further, funding supports Government Owned, Contractor Operated (GOCO) AAPs and critical machine tooling for the private sector. Investments at the three Army Working Capital Fund (AWCF) ammunition installations are included in the price of ammunition. Supplemental funding is required to support critical industrial base improvements required to support increased GWOT, training, and modularity ammunition production requirements**.** [179]

A 2007 SMCA/PEO Ammunition Integrated Process Team (IPT) identified over 100 core ammunition process capabilities. Fifty-one of the core processes were judged to be unique Single Point Processes with capabilities not found at other facilities within the National Industrial Technology Base (NTIB). Many core processes were found to be in need of critical modernization and right sizing efforts. Processes included Milan AAP's 40mm ammunition and the fuze capabilities, Crane AAA's demolition block line, many of the Pine Bluff ammunition capabilities including illuminating mortar and artillery lines, the infrared (IR) mortar lines and the smoke grenade lines. The Iowa AAP's tank training ammunition production capability and many of the McAlester AAP's bomb lines are core processes. Holston AAP propellants and explosives capabilities for RDX and HMX are core processes with Single Point Process capabilities not found at other facilities within the NTIB.

The IPT also studied "actual**"** plant capability and capacity utilization rates for the period of FY01 to FY03, and "projected" plant capability and capacity utilization rates for the period FY04 through FY06. A significant number of the plant utilization rates were found to be less than 50%, some were found to be as low as 10% at Lone Star and Kansas AAP facilities. Two of the core processes found at Radford and Lake City AAPs were found to have utilization rates above 60%, one had a utilization rate of 95%. Many of the core processes were also found to be in need of critical modernizations. They included the Radford AAP nitrocellulose and nitroglycerin processes, Lake City AAP small caliber ammunition lines and many of the facility infrastructure assets and steam plants.[180]

In FY09, JMC and PM Joint Services submitted over $200 million in infrastructure efforts to DA in support of a potential stimulus package requested by President Barrack Obama. Projects identified were extracted from the FY 10-15 Production Base Support Industrial Facilities program. Additionally, the Installation Management's Command's (IMCOM) list of Military Construction Army (MCA) projects totaling $2.2 billion which includes projects from JMC installations was also submitted for consideration. The JMC's MLRC directorate

[179] AFSC/JMC History Office. "FY05 Program Executive Office for Ammunition AHS," *AFSC/JMC FY05 Annual Command History*.
[180] *Ibid.*

developed and supported the briefing package to the Chief of Staff, Army for an industrial base modernization plan on 13 December 2008. The CSA supported the plan and committed a funding stream to execute the plan. The plan provides for safe, environmentally-improved, properly sized and efficient facilities.

Summary

The history of the ammunition industrial base has provided lessons and generated many studies into how to obtain a right-sized base. Long lead times at the outbreak of war have shown that it is essential to maintain necessary funding for a warm base. This paper has traced the evolution of the industrial base from creation to present day to provide a comprehensive look at many of the challenges and initiatives made to correct deficiencies for ammunition. A discussion on the emergence and operation of the SMCA provided a brief background on Army's management of conventional ammunition. Important information on the depot system designed to store conventional ammunition is not included. As ordnance leaders and studies indicated, the ammunition base lacked necessary maintenance and modernization funding during peacetime in order to maintain a properly sustained warm base.

As technology and modernization have created more advanced production capabilities and threats of world wars have diminished, the Army has become adept with a smaller base and improved acquisition strategies to integrate commercial producers in times of urgent need. As requirements decreased and budgets were cut at the end of the Cold War, the Army and ammunition community evolved to meet the changing dynamics of modern needs. The industrial base must remain flexible, adaptable, and responsive. The transition to precision guided munitions (PGM) and accuracy on the battlefield lead the future, but still requires core processes in the industrial base. Conventional ammunition is a commodity that will remain an essential part of ammunition supply and must be properly funded to rapidly meet requirements. A great deal of responsibility has been placed upon the new life cycle management structures to maintain and improve an industrial base that is strong enough to meet any requirements. Management of the ammunition life cycle will continue to streamline production, acquisition, and logistics in the ammunition industrial base.

The ammunition community continues to think critically about excess production capacity and idle facilities at the remaining government ammunition plants. The latest BRAC 2005 round has closed an additional five sites, reducing the total number of Army ammunition production facilities to twelve, three depots, and 2 munitions centers in 2011. As discussed, The JM&L LCMC, JMC, PEO AMMO, and ARDEC are implementing new acquisition strategies and utilizing new management/measurement tools to ensure that requirements and surge capabilities can be met. The possibility of further ammunition base funding cutbacks will be imminent in the future if assumptions are based on historical patterns. Ammunition funding must remain constant in the minds of decision makers and leaders to avoid ammunition shortages in the event of future contingencies.

APPENDIX A - WWII AMMUNITION PLANTS [181]

DATE APPROVED	NAME & LOCATION	PRODUCT	OPERATING CONTRACTOR
10 April 1942	Allegany Ord. Plant - Cumberland, MD	.30 cal Armor Piercing Ammunition	Kelly Springfield Engineering Company
23 Jan 1941	Alabama Ord. Works #1 - Sylacauga, AL	Smokeless Powder, DPA, DNA	E.I. Dupont de Memours & Co. Military Explosives Division
30 June 1941	Alabama Ord. Works #2 Sylacauga, AL	Bellite, DNT, Tetryl, Oleum, TNT	E.I. Dupont de Memours & Co. Military Explosives Division
19 July 1941	Arkansas Ordnance Plant – Jacksonville, Arkansas	Fuze, Prime., Per., Elate. Det., Delay	Ford , Bacon & Davis, Inc.
1 Feb 1942	Badger Ordnance Works – Badger, WI	Smokeless Powder, Oleum, E.C. Pwder	Hercules Powder Co.
23 Oct 1943	Baytown Ord. Works – Baytown, TX	Tolunul	Humble Oil Ref. Co.
11 Feb 1942	Bluebonnet Ord. Plant – McGregor, TX	Shells, Bomb Cluster, Demolition Blocks, Bombs	National Gypsum Co.
13 Dec. 1941	Buckeye Ord. Works – South Point, OH	Anhydrous Ammonia	Atmospheric Nitrogen Corp.
14 Sep. 1953	Cactus Ord. Works – Dumas, TX	C-3	Shell Union Oil Corp.
10 July 1942	Cherokee Ord. Works – Danville, PA	Formaldehyde & Hexamine	Heyden Chemical Co.
26 Jan 1942	Chickasaw Ord. Works – Millington, TN	TNT, DNT, Smokeless Powder	E.I. Dupont de Memours & Co. Military Explosives Division
20 Feb. 1941	Coosa River Ord. Works – Talladega, AL	Bag & Igniter Loading, Rockets	The Brecon Loading Co.
3 Mar. 1942	Cornhusker Ord. Plant – Grand Island, NE	Bomb & Shell Loading	Quaker Oats Ord. Corp.
12 Aug. 1942	Dixie Ord. Works – Sterlinton, LA	Anhydrous Ammonia	Commercial Solvents Corp.
18 July 1941	Des Moines Ord. Plant – Des Moines, IA	Small Arms Ammo, .30 & .50 cal	U.S. Robber Co.
10 Dec. 1940	Denver Ordnance Plant - Denver, CO	.30 cal ammo	Remington Arms Co.
16 Oct 1942	Detroit Cup Plant – Detroit, MI	.30 cal steel cartridge case cups	Parker-Wolverine Co.- Ordnance Division
6 Oct 1941	East Tennessee Ord. Works – Copperhill, TN	Oleum	Tennessee Copper Co.
21 Sept. 1940	Eau Claire Ord. Works - Eau Claire, WI	.30 cal incendiary and ball	U.S. Rubber Co.
21 Sept 1942	Elwood Ord. Plant – Joliet, IL	Shell & Bomb Loading, primers, detonators, fuzes & boosters, amatol & ammonium nitrate	Sanderson & Porter
13 March 1942	Evansville Ord. Plant – Evansville, IN	.30 cal carbine & .45 cal	Chrysler Corporation & Sunbeam Electic Mf. Co.
1 Oct 1940	Gadsden Ord. Plant –	Shell Forging and	Lansdowne Steel & iron

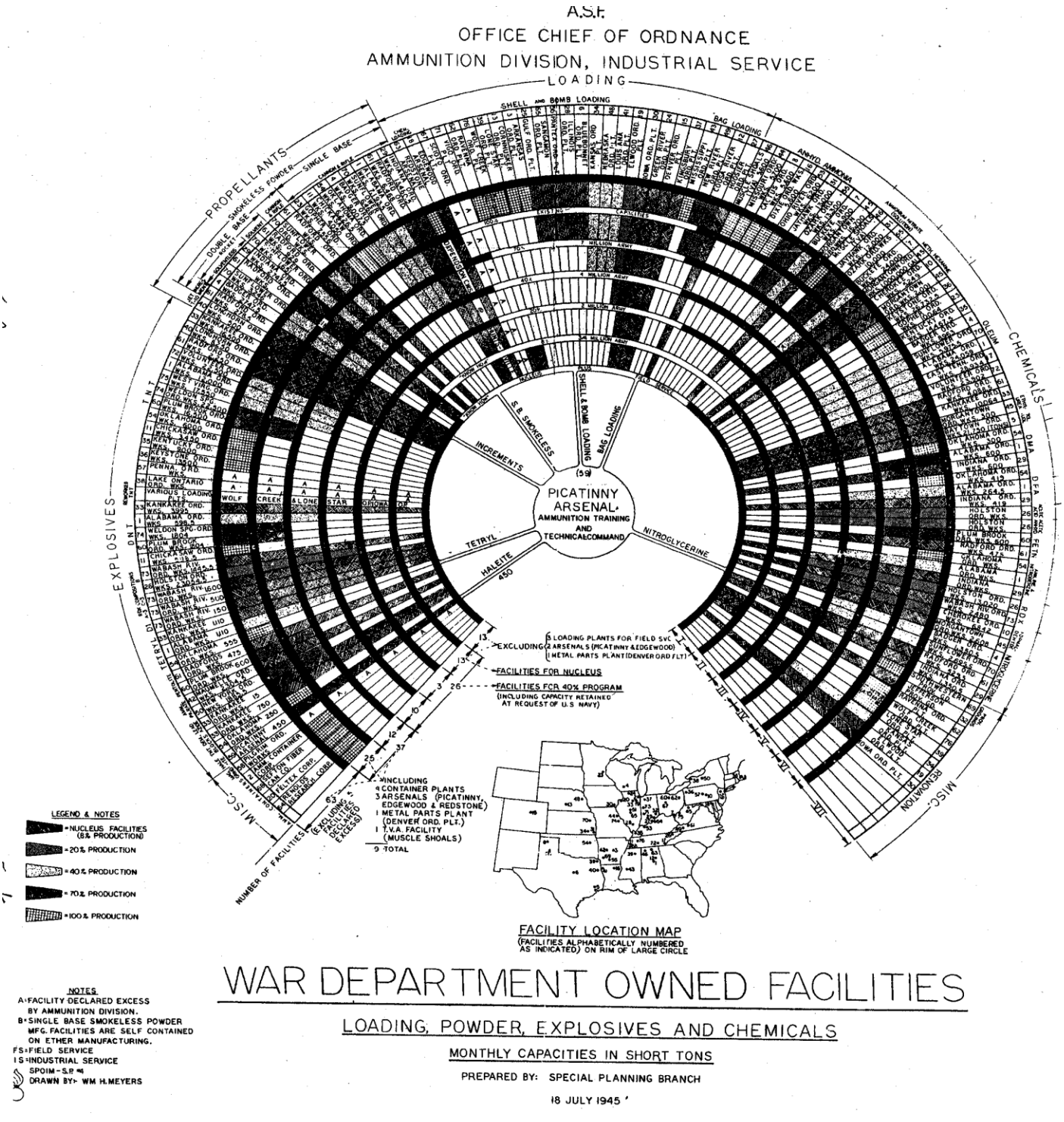
[181] This list is representative of the majority of ammunition plants that operated during the WWII. Data obtained from a 1944 Field Director of Ammunition Plants (FDAP) Data of Ammunition Plants List & Office of the Chief of Ordnance, *Ammunition Plant Directory* (DA, Office of the Chief of Ordnance: 1946) passim.

	Gadsden, AL	Machining for 105mm shells	Co.
1 May 1942	Gopher Ord. Works – Rosemont, MN	Smokeless Pwdr, Oleum	E.I. Dupont de Memours & Co. Military Explosives Division
4 Feb 1942	Green River Ord. Plant – Dixon, IL	Shells, Grenades, bombs, Rockets, and fuze loading	Stewart Warner Corp.
16 April 1942	Gulf Ord. Plant – Aberdeen, MS	20mm, 40mm, and 57mm Ammo, 4.5 inch H.E., rockets, tracers and fuzes	Proctor and Gamble
12 June 1942	Holston Ord. Works – Kingsport, TN	RDX, Comp. B	Tennessee Eastman Corporation
3 Jan 1941	Hooser Ord. Plant – Charlestown, IN	Bag & Igniter Loading	Goodyear Engineering Corporation
21 Aug 1941	Illinois Ord. Plant – Carbondale, IL	Shells & Bombs	Sherwin-Williams Defense Corp.
19 July 1940	Indiana Ord. Works – Charlestown, IN	Smokeless Powder, DMA, DPA	E.I. Dupont de Memours & Co. Military Explosives Division
6 Nov. 1940	Iowa Ord. Plant – Burlington, IA	Shells, Mines, Bombs, Fuzes, Det. Boosters, Primers, TNT	Day & Zimmerman, Inc.
18 Sept. 1941	Jayhawk Ord. Plant – Baxter Springs, KS	Anhydrous Ammonia, Ammonia Nitrate	Military Chemical Works
13 Sept. 1940	Kankakee Ord. Works – Joliet, IL	TNT, DNT & Tetryl, Lead Azide, Oleum, TNT Blocks	E.I. Dupont de Memours & Co. Military Explosives Division
9 Aug. 1941	Kansas Ord. Plant – Parsons, KS	Shell Loading, Boosters, Propellant charges	J.M. Service Corporation
3 March 1942	Kentucky Ord. Works – Paducah, KY	TNT, Oleum	Atlas Powder Co.
8 Dec. 1941	Keystone Ord. Works – Geneva, PA	TNT, Oleum	Fracer Bruce Engineering Co. Inc.
8 Nov. 1940	Kingsbury Ord. Plant – Le Porte, In	Shells, Mines, Fuzes, Canister, Bomb Cluster, Armor Piercing Ammo, Grenades, Anti-Personnel Mines, 20mm, 37mm, 40mm, 60mm, 75mm, 3 Inch and 105mm ammo	Todd & Brown Inc.
5 Jan. 1942	Kings Mills Ord. Plant – Warren County, OH	.30 cal carbine ammo	Remington Arms Co.
20 Nov 1940	Lake City Ord. Plant – Independence, MO	.30 ball, AP, Tracer & .50 cal AP, Tracers, and incendiary, .30 cal carbine, .30 carbine grenade	Remington Arms Co.
29 Dec 1941	Lake Ontario Ord Works – Youngstown, NY	TNT	Chemical Construction Corporation
22 Dec 1941	Longhorn Ord. Works – Marshall TX	TNT	Monsanto Chemical Corp
20 July 1941	Lone Star Ord Plant – Texarkana TX	Loading Plant – Artillery shells, bombs, fuzes, boosters and tracers	Lone Star Defense Corp. (BF Good Rich Corp)
10 July 1941	Louisiana Ord. Plant – Shreveport, LA	Ammo AP, Shells, 1000 lb pounds, grenades, rifle grenades, ammonium nitrate, boosters, fuzes,	Silas Mason Co.

15 July 1941	Maumelle Ord. Works – Little Rock, AK	Ammonium Picrate	Cities Service Defense Corp.
27 March 1942	Lowell Ord Plant – Lowell MA	.50 AP Ammo, brass case, .50 cal AP Steel case, & .50 ball	Remington Arms Co.
17 Aug 1942	Milwaukee Ord Plant – Milwaukee, WI	.50 cal	U.S. Rubber Co.
4 Aug 1941	Mississippi Ord. Plant – Flora, MS	Planned to make propellant bags for artillery - Placed on standby	General Tire Engineering Co.
19 Aug 1941	Missouri Ord. Works – Louisiana, MO	Anhydrous Ammonia	Hercules Powder Co.
29 Nov 1940	Morgantown Ord. Works	Anhydrous Ammonia, Hexamine, Formaldehyde and Methanol	E.I. Dupont de Memours & Co. Military Explosives Division
12 Dec. 1941	Nebraska Ord. Plant – Fremont, NE	Bombs, boosters, & Ammonium nitrate	Nebraska Defense Corp.
21 Dec 1941	New River Ord. Plant – Pulaski, VA	Powder Bag Loading, & Special Propellant Charge Loading Plant	Hercules Powder Co.
23 March 1942	New York Ord. Works – Baldwinsville, NY	Standby	National Aniline Defense Corp.
15 Feb. 1941	Ohio River Ord. Works – Henderson, KY	Anhydrous Ammonia	Atmospheric Nitrogen Corp.
13 Sept. 1941	Oklahoma Ord. Works - Pryor, OK	Smokeless Powder, ACP, NAC, SAC, DPA, TNT, Tetryl, TNT Demo blocks	E.I. Dupont de Memours & Co. Military Explosives Division
25 Nov. 1941	Ozark Ord. Works - El Dorado, Arkansas	Anhydrous Ammonia & Ammonium Nitrate	Lion Chemical Corp.
10 March 1942	Pantex Ordnance Plant – Amarillo, TX	250 LB Bombs, 500 lb. G.P. bombs, 23 lb. Fragmentation bomb, 105mm howitzer shells, ammonium nitrate boosters	Certain-Teed Products Corp.
31 Dec. 1942	Plub Brook Ord. Works, - Sandusky, OH	TNT, NDT, Pentolite	Trojan Powder Co.
7 Jan 1942	Pennsylvania Ord. Works – Williamsport, PA	TNT	U.S. Rubber Co.
10 April 1942	Pilgrim Ord. Works – West Hanover, MA	Magnesium Metal Powder	National Fireworks Inc.
16 Aug 1940	Radford Ord. Works – Radford VA	Nitrocellulose Powder, pentolite, TNT	Hercules Powder Co.
Aug 1940	Ravenna Ord. Plant – Apco, OH	Shells, Boosters, Primers, Loading bombs, ammonium nitrate, renovating ammo from outside sources	Atlas Powder Co.
	Redstone Arsenal - Huntsville, AL	Load and assembly of 75, 81, 105 and 155 mm gas and smoke shells, demo blocks,	Ordnance Dept.
20 Feb 1942	Sangamon Ord. Plant- Springfield IL	Shells, Fuzes, Boosters	Remington Rand Corp.
5 Dec 1940	St. Louis Ord. Plant - St. Louis, MO	.30 and .50 cal ammo	U.S. Cartridge Co.

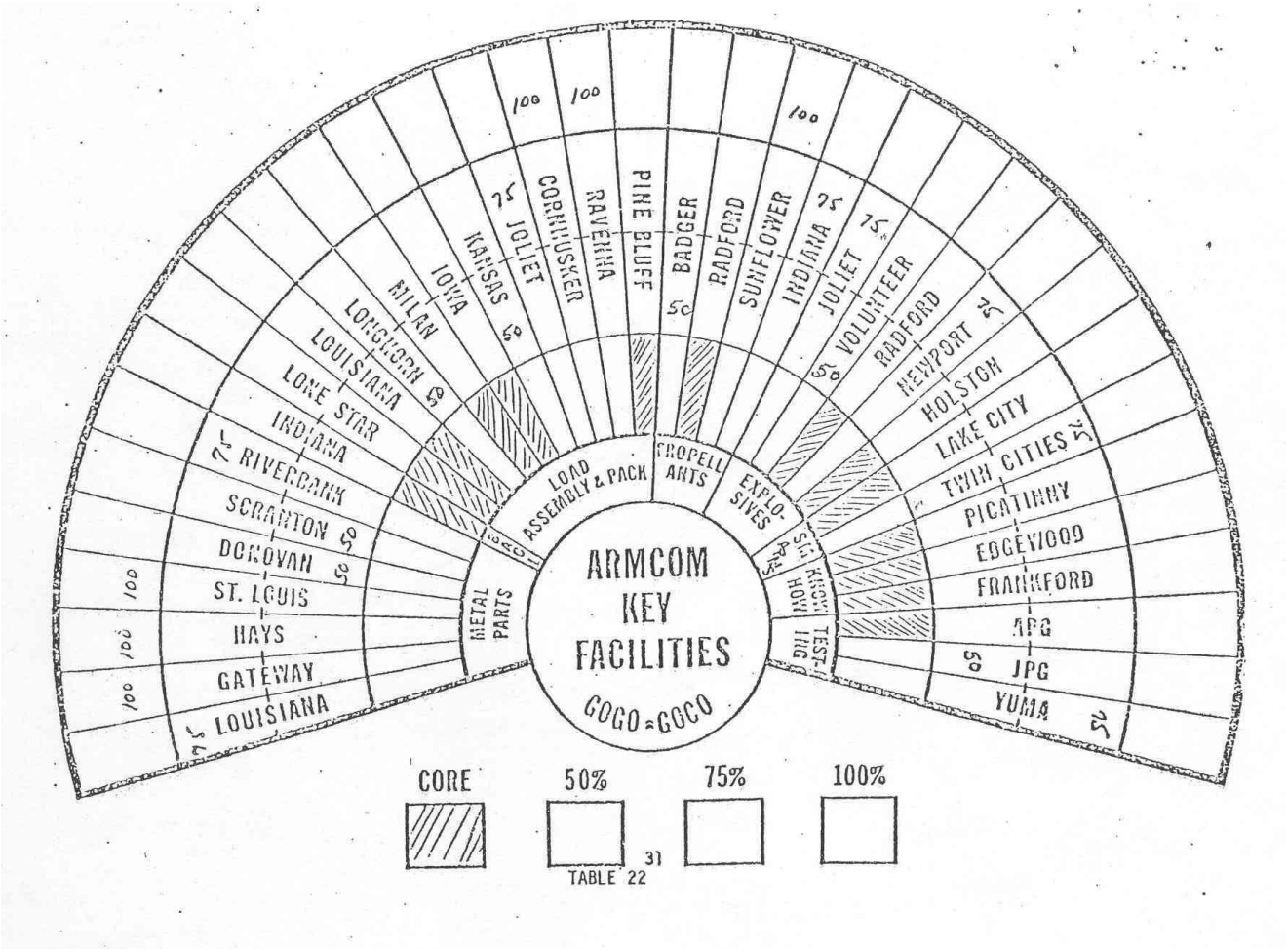
14 May 1942	Sunflower Ord. Works – DeSoto, KS	Smokeless Powder, Rolled Strip & Extruded Double Base Powder, Certain Stick Powders, Oleum	Hercules Powder Co.
18 Nov 1943	Scioto Ord. Plant – Marion, OH	Fuzes, Boosters – Converted to .50 cal ammo	U.S. Rubber Co.
14 July 1941	Twin Cities Ord. Plant – New Brighton, MS	.30 cal. ball, .50 cal.	Federal Cartridge Co.
30 July 1942	Utah Ord. Plant – Salt Lake City, UT	.30 & .50 cal. ammo	Remington Arms Co.
7 March 1942	Vigo Ord Plant – Terre Haute, IN	LAP	Concan Ord. Co. Inc
Not Provided	Virginia Ord. Works – Glen Wilton, VA	TNT	Not Provided
19 August 1941	Volunteer Ord. Works – Chattanooga, TN	TNT, Nitric Acid, Oleum, Sellite	Hercules Powder Co.
12 Dec 1941	Wabash River Ord. Works	RDX & explosives	E.I. Dupont de Memours & Co. Military Explosives Division
25 Oct 41	Weldon Springs Ord. Works - Weldon Springs, MO	TNT, DNT	Atlas Powder Co.
29 Jan 1942	West Virginia Ord. Works- Point Pleasant, WV	TNT, Comp B, C-2, C-3	General Chemical Defense Co.
31 Dec 40	Wolf Creek Ord. Plant – Milan, TN	Shells, Bombs, Bomb Clusters, Tracer, Rocket, Fuzes, Tetryl Pellet	Proctor & Gamble Corp.
	AMMO CONTAINER	**FACILITIES**	
22 Oct 1941	Ammo Container Corp. – Chicago, IL	Ammo Containers	American Can Co.
18 Oct 1941	Feltex Corp. – Fiber Container Corp. – Rock Island, IL	Ammo Containers	Feltex Corp.
18 Oct 1941	Sefton Fiber Can Co. – Memphis, TN	Ammo containers	Reynolds Metals Co.
	DEPOTS		
6 Sep 1943	Anniston Ord. Depot – Anniston AL	Receipt, Storage & Issue of Ord. Materiel	Anniston Whae. Corp
23 Sept 43	Blue Grass Ord. Depot – Richmond, KY	Receipt, Storage & Issue of Ord. Materiel	Blue Grass Ord. Depot Inc
11 Aug 1943	Lordstown Ord. Depot – Warren, OH	Receipt, Storage & Issue of Ord. Materiel	Lordstown Depot Mgt. Inc.
31 Dec 40	Milan Ord. Depot – Milan, TN	Receipt, Storage & Issue of Ord. Materiel	Proctor & Gamble
28 Aug 40	Portage Ord. Depot – Wayland, OH	Receipt, Storage & Issue of Ord. Materiel	Atlas Powder Co.
12 Aug 1943	Rossford Ord. Depot – Toledo, OH	Receipt, Storage & Issue of Ord. Materiel	Harvester War Depot, Inc.

APPENDIX B
WWII ERA GOVERNMENT OWNED AMMUNITION INDUSTRIAL BASE [182]



[182] Hammond, 5. This diagram reflects WWII era LAP, propellant, explosive and chemical facilities owned by the War Department. The chart was created to show what facilities were operating or could be utilized for supplying 1-7 million man Army forces. The 12 small arms plants operating during WWII are not included in this chart but were also War Department assets.

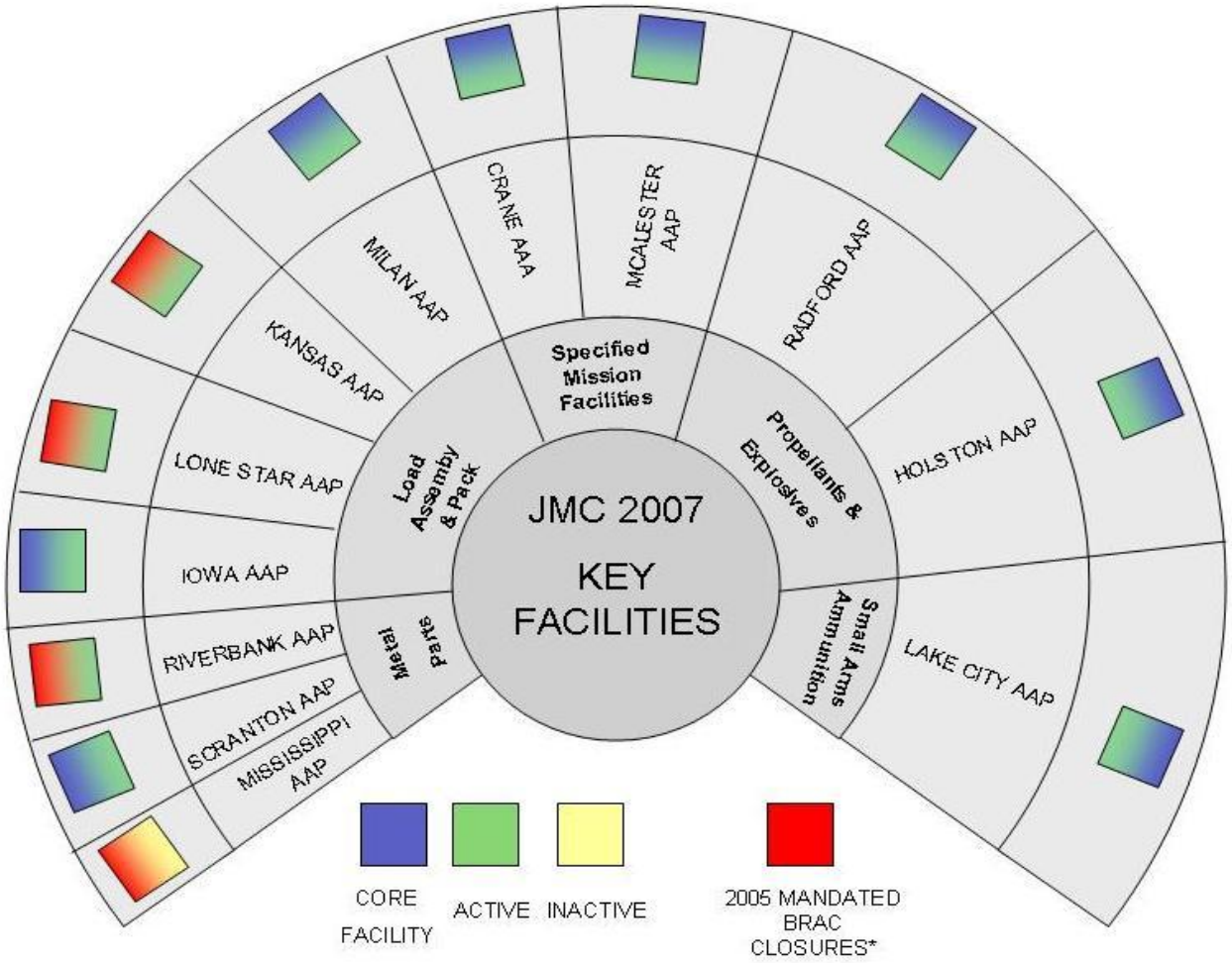
APPENDIX C
1977 GOVERNMENT OWNED AMMUNITION INDUSTRIAL BASE



This table represents the same technique for displaying core facilities. The diagram illustrates which other plants had capacity for reactivation to support a surge or full-scale mobilization. Core facilities were determined by degrees of: versatility, product capability, modernization, competitiveness, and essentiality. The core plant complexes were and are considered essential to retain to provide the minimum level warm base capabilities needed to produce ammunition components and end items. In 2007, all the plants that were *not* identified as core processes in this chart have been closed. In addition, Frankford Arsenal, Indiana Army Ammunition Plant, and Louisiana AAP were removed from the core critical process ranking and are no longer part of the base. [183]

[183] Hammond, Table 22 – After p. 123.

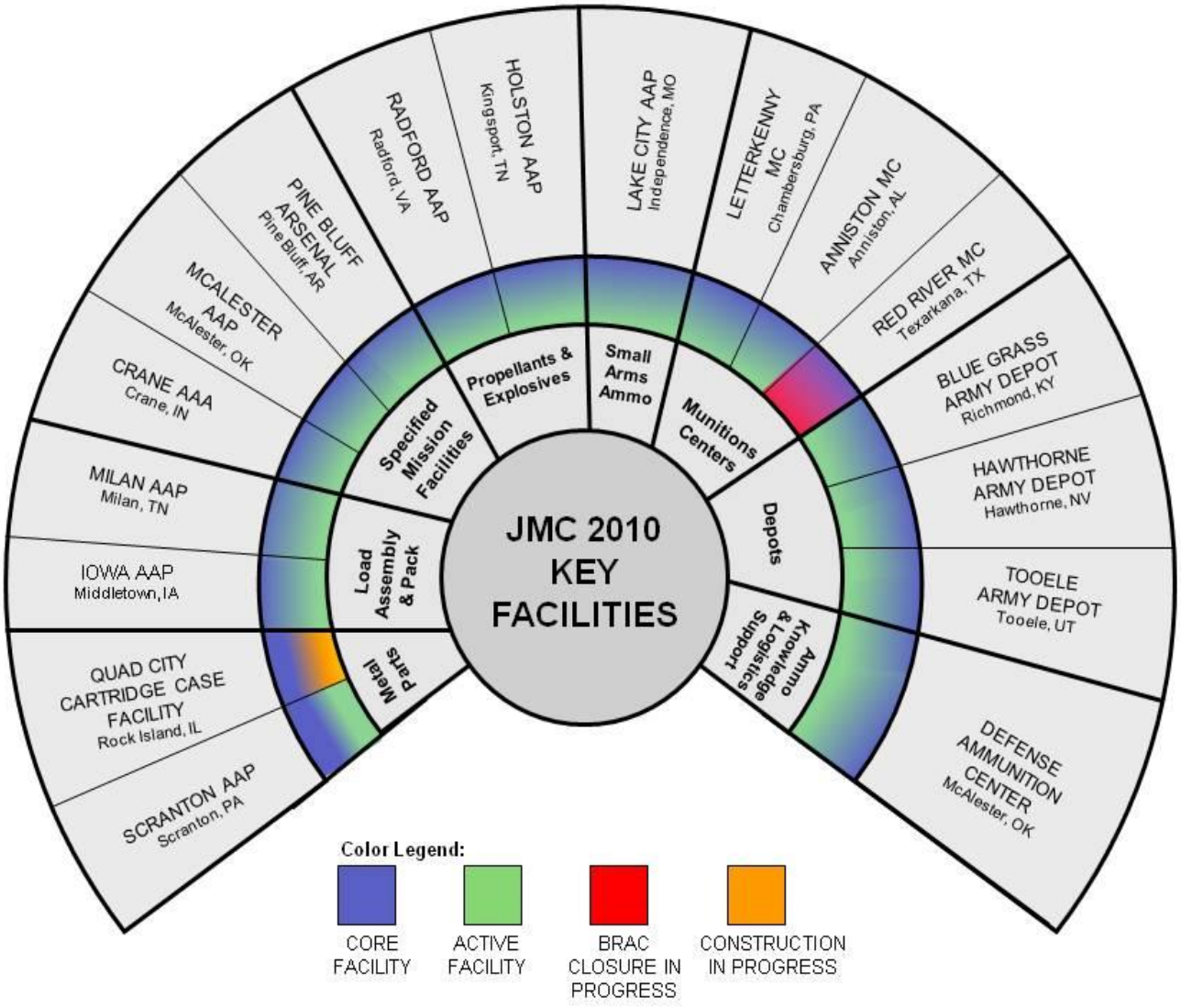
2007 GOVERNMENT OWNED AMMUNITION INDUSTRIAL BASE



* The capabilities located at closing plants are being realigned to other installations. BRAC target completion date for closures is the end of FY11.

This diagram reflects the ammunition industrial base in 2007. JMC closed four plants by FY2011 and transferred land management functions to BRAC-D to work on the transfer of land to local or gaining authorities.

2010 GOVERNMENT OWNED AMMUNITION INDUSTRIAL BASE



This diagram reflects the ammunition industrial base in 2010. JMC closed four installations: Riverbank AAP, Mississippi AAP, Lone Star AAP, and Kansas AAP between FY09-10. Pine Bluff Arsenal transferred from the Chemical Materials Agency to JMC in 2008. Red River Munitions Center will be closed by the end of FY11. The total core/key ammunition production and storage facilities managed by JMC in 2010 totaled 16. No production is completed by Defense Ammunition Center (which would total 17).

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