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Report of the Fiscal Year 2023 Study

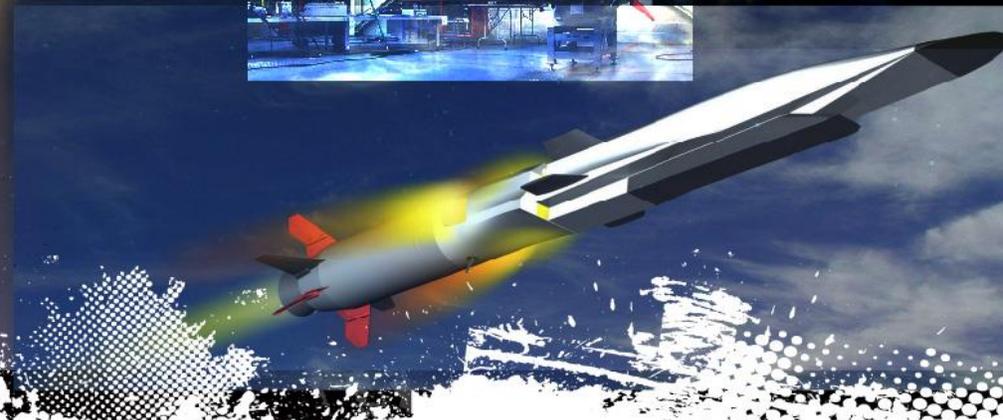
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Surge Capacity in the Defense Munitions Industrial Base

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The Army Science Board (ASB), organized under the Federal Advisory Committee Act (FACA) in 1977, provides the Army with independent advice and recommendations on matters relating to the Army's scientific, technological, manufacturing, acquisition, logistics and business management functions, as well as other matters the Secretary of the Army deems important to the Department of the Army.

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EXECUTIVE SUMMARY

The Army's Organic Industrial Base (OIB) and the commercial Defense Munitions Industrial Base (DMIB) both face systemic issues with supply chain fragility and are currently struggling to ramp up the production of munitions. This state of affairs has been obscured for years by faulty planning assumptions, peacetime requirements, and complex chains of authority within the Army. Recent responses to crises such as the war in Ukraine and COVID-19 have revealed many fragilities. For example, the Army lacks surge capacity for several systems it procures, evident by a decline in general capacity over the past thirty years. Over fifty mergers and acquisitions within the DMIB have left five primes in control of the market, while inconsistent funding has discouraged industry investments. Twenty years of fighting low intensity conflicts have eroded inventories and provided false confidence in the ability of industry to meet production needs.

This study provides findings and recommendations regarding munitions requirements, governance, sustainable procurement, capital investment, contracting, and other issues in the OIB/DMIB. The study team focused its findings to describe impacts on the Army's procurement of munitions:

- Formal processes are in place to establish munitions requirements, but Army senior leaders have no visibility of risks or tradeoffs.
- Munitions must also compete for modernization funds which historically are then cut to pay other bills, based on an assumed ability of the DMIB to surge capacity.
- The Army typically has no single authority which oversees end-to-end enterprise munitions matters, such as quantity and lethality requirements, the monitoring and mitigating of low demand signals to the OIB and DMIB, the definition and establishment of minimum sustaining rates, the elimination of single points of failure, or the adjudication of disputes between munitions managers.
- The Single Manager for Conventional Ammunition (SMCA) authorities are limited in scope to conventional munitions and are dispersed between Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA(ALT)), Joint Program Executive Officer, Armaments and Ammunition (JPEO A&A), and Army Material Command.
- A review of contracting found that industry uniformly complained of slowness of contracting and delayed investment decisions, hindering industry's timely response to wartime demands, while smaller businesses have been squeezed by inflation concerns.
- Contracting personnel's incentives do not align with their Army Program Manager customers, and the complexity of the Federal Acquisition Regulation (FAR)/Defense Federal Acquisition Regulation (DFAR) arrangements creates inefficiency.

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- Army facilities support Army munitions requirements and surge demands, as well as those of the other Services. The Army has been able to manage competing demands during the past 20 years of counter insurgency (COIN) and counter terrorism operations, as these operations did not overwhelm the system.

Industrial concerns and constraints are focused on the issues of sustainable procurement and capital investment. For sustainable procurement, industry requires consistent signals from the government to build and sustain surge capabilities. Multiyear contracts with increased caps and minimum sustaining rates would incentivize industry investment, as well as mitigate single points of failure. S&T and R&D could be better leveraged across the defense munitions industrial base (DMIB) to reduce reliance on foreign sources of raw materials. In terms of capital investment, there has been a decades-long signal from government to industry to put cost control and efficiency above all else, continuously sacrificing surge capacity and deterring against modernizing industrial facilities with advanced manufacturing techniques. While major investments are underway, further investment is needed as industry is reluctant to assume risk and try new methods and programs, such as new energetics programs.

Current progress is underway but remains slow. The Army today has initiated a 15-year modernization plan for the aging facilities that make up the OIB, allocating \$0.5 billion in 2023, and \$2.5 billion in FY24-28. However, challenges remain, including over one hundred single points of failure throughout the supply chain, continued reliance on foreign sources of key raw materials, failure to address future needs, and no risk mitigation plans for stockpiling or developing alternatives for critical materials.

The study concluded that there are several areas where the Army can improve its efforts in the near-term. Some recommendations include:

- Creating a single authority to oversee resourcing including other considerations, such as capital investment and execution.
- Examining initiatives to strengthen unity of command, with the aim of simplifying control of munitions procurement and defining the roles of the PEOs and the Joint Munitions Command.
- Focusing efforts on analyzing future strategic munitions needs, to better prioritize availability for critical munitions with long lead times. This could be addressed through the use of larger (>\$500 million) funding caps on multiyear procurement deals to develop minimum sustaining rates for munitions.
- Expanding the use of cheaper and more attritable munitions (munitions with shorter, limited lifetimes), which could be readily used for training or sale to foreign militaries.

- Funding a flexible pilot plant line to explore methods of developing new explosive synthesis, jumpstart the adoption of new manufacturing technology, and ultimately create a model that would lessen reliance on foreign sources.

Follow-on studies are recommended, including streamlining the FAR/DFARS to enhance contracting responsiveness, evaluating changes to GOCO plant operations as a model for the future manufacturing within the OIB, and exploring the application of advanced manufacturing techniques within the OIB and DMIB.

The study team's recommendations are aimed at improving the Army's munitions production effort, ensuring readiness, and strengthening both the commercial and organic industrial bases.

To be clear, these recommendations appear to mitigate much of the production risk exposed by demands stemming from the Ukraine conflict as we are aware of it today. However, the study team is concerned that the industrial base (organic and commercial) may be incapable of meeting the munitions demand created by a potential future fight against a peer adversary. Recently publicized CSIS analysis of a U.S. conflict with China exposes significant shortfalls that go beyond this study's recommendations. Further analysis in this regard is also warranted.

BACKGROUND

Surge requirements to support the war in Ukraine, combined with the effects of the COVID-19 pandemic on the global work force, have exposed increasingly brittle supply chains supporting national security capabilities. As DoD requested the DMIB to ramp up production of munitions and foreign military sale (FMS) items to refill stockpiles and provide support to Ukraine, industry responded with long lead times, complicated by single points of failure, and worrying dependencies on fragile, foreign sources of supply. Those shortfalls raised additional concerns over whether and how these challenges might also impact operations in any near-term U.S. INDOPACOM theater initiatives.

In response, the Secretary of the Army SECARMY requested the Army Science Board (ASB) to examine efforts that would build resiliency and depth in the industrial base by 2025.



Terms of Reference (TOR) & Assumptions

TOR Background:

1. The war in Ukraine and the COVID-19 pandemic exposed systemic problems with supply chains supporting national security capabilities.
2. Munitions industrial base is currently incapable of rapidly ramping up to meet crises like Ukraine.

TOR Tasks:

1. Identify and understand current Army ecosystem's efforts and plans related to munitions production.
2. Examine industry practices, concerns, and constraints.
3. Recommend near-term actions to facilitate improved surge capacity by 2025.
4. Determine whether there are new or updated governance, policy, procedures, and initiatives to enable the Army's and industry's ability to surge in response to a crisis.

Framing Assumptions:

1. In order to be prepared for conflict in 2027, we need to take steps now.
2. CONUS will not be a sanctuary in a conflict with a peer competitor
3. An analysis of wartime munitions expenditures will provide insight on actual requirements, a measure of the DIB's ability to meet the requirements, and a survey of gaps between the two.
4. The examination of the GOCO/GOGO business model, as well as its efficiency and effectiveness, is out of scope for this short-term study
5. An in-depth examination of the commercial supply chain was out of scope for this short term study
6. This study focuses primarily on select Army conventional munitions

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SECARMY directed the team to do a quick-turn analysis providing findings and recommendations that staff could consider in creating the Army's next five-year spending plan, the Program Objective Memorandum (POM). That set the team's deadline to produce observations to May 2023, before the Army's POM deadline. The study team's effort also reflects the assumption that if China continues along an aggressive path in the Western Pacific, the U.S. may face some level of conflict by 2027. In that case, the Army will need to be ready by 2025, necessitating program planning now.

The short-term nature of the study led the team to narrow the scope to focus on conventional Army munitions and on changes to current governance, policy, procedures, and initiatives that could assist the Army and industry to surge production. It also precluded following some lines of inquiry, such as analyses of Government-owned, Government operated (GOGO) and Government owned and commercially operated (GOCO) facilities. For example, the study team did not look at the efficiency and effectiveness of their operations or the business model of producing some munitions organically versus outsourcing to commercial industry. The study was unable to perform an in-depth examination of the complete commercial supply chain but did focus on some of the reasons DoD and industry have been unable to respond and ramp up to meet crises like Ukraine. It also reviewed near-term investments in technology that could assist in developing new capabilities in both the short- and long-term. The study team believes continued fighting in the Ukraine and a possible Indo-Pacific conflict will redefine U.S. munitions requirements, and the study team’s observations will reflect the need to reach those higher levels.



Methodology

- 30+ semi-structured interviews with the Army, DOD, industry and academia
 - ASA(ALT), G-3, G-8, JPEO A&A, PEO M&S
 - OUSD A&S
 - Northrop, GD, Raytheon, BAE
 - Small Businesses
 - Industry Consortia and universities
- Further surveyed small businesses via a Request for Information (RFI) published in the Federal Register
- Based the interviews and RFI on ~15 consistent question sets
- Literature review of 30+ studies, testimony, articles

STUDY TEAM

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The study team was comprised of individuals with expertise in Army operations, engineering, systems engineering, public policy, international relations, and physics. Team members’ experience included work on defense issues in both the legislative and executive branches, corporate leadership, academics, and military operations.

The study team performed an extensive review of the literature that informed the lines of inquiry used for interviews and a Request for Information (RFI) to industry. In addition, the team conducted over 30 exploratory interviews with a mix of large and small businesses, industry consortia, Government, and academia which provided a range of perspectives on the tasks in the

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Terms of Reference (TOR). By no means was the information gathering exhaustive, but the team collected data from a sufficient cross-representation of the stakeholders (see Appendix C). The RFI responses, received from several companies, were consistent with and reinforced what the team learned from data gathering interviews.



The dramatic consolidation of the defense industrial base in the 1990's, a response to the defense budget cuts at the end of the Cold War and explicit direction from Pentagon leaders, led corporations to adopt their customer priorities: value and lowest cost bids, even as DoD's demand fell dramatically. "Winner-take-all" awards increased while funds to support alternative suppliers as a backup, and even competition in contracts, largely disappeared.

The few vendors that remained in the market reduced personnel and operations to minimum levels to keep their remaining production lines profitable. Often, this involved identifying and maintaining the highest revenue-generating production lines and cutting less profitable ones. It also led to a just-in-time model for production that does not keep parts or supplies on hand in case of emergency. Over these same decades, DoD divested of its "excess" inventory, including storage facilities, through base closure rounds.

The ongoing push toward optimization has also driven key manufacturing capabilities offshore, led to the depletion of bench stocks, and allowed supply chains to atrophy in the absence of any requirement to surge manufacturing.

The Pentagon's many acquisition rules and regulations have created a highly concentrated traditional defense industry on which the military relies for equipment, technology, and

weapons. With few and inconsistent DoD orders, the DMIB has little incentive to invest in itself or to innovate without government direction and resources.



Pernicious Effects of Volatile Funding on the EcoSystem

Munitions have evolved, but facilities, supply chains, and many processes have not.

- The burn down of Cold War munitions stockpiles and cost-capped procurement has produced a reduced, overly lean munitions industrial base that is slow to respond to potential surges
- Inconsistent funding > 20 years discourages industry investment
- Historically, cuts of 13-20% before funding a contract has led industry to not invest prior to award
- Single year contracts introduce higher costs vs. multi-year contracts
- “Cold” lines take 18 mos. to re-start
- Environmental/safety regs. add constraints on surge production



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Fragility across the OIB and commercial DMIB includes World War II-era (or older) facilities, outdated machinery and production techniques, inadequate tooling, foreign sources of supply, poor visibility of suppliers, insufficient tested and validated long lead-items, and workers who have exited or retired. In several cases, key parts required to keep manufacturing lines open no longer exist and are difficult to replace.

Responding to fiscal cuts in 2010, the Army accepted risk with munitions production. The decision was based, in part, on the munitions expenditure rates observed in Iraq and Afghanistan, which showed that large quantities of 155mm artillery shells were not required. Subsequently, the Army continued to reduce its ammunition production to meet further spending reductions imposed by sequestration resulting from the Budget Control Act of 2011. Budget decisions made at the time aligned with national security risks and priorities, but the lack of steady funding disincentivized the DMIB from investing in facilities, modernization, or advanced manufacturing capabilities.

When projections and programmed funds for munitions form a wavelength, i.e., there are no steady and predictable levels of production, costs increase, and timelines grow. Consequently, ammunition programs are often a source of funding for higher priorities, exacerbating any impending shortfalls.



Industrial Capacity Replenishment

Program	Organic Investment \$M	Defense Investment \$M	Current Production Rate per month	Future Production Rate per month	Future Production Deliveries Begin
Stinger		\$62	40	60	2QFY25
Javelin LWCLU		\$72.02	17	41	4QFY23
Javelin Missile		\$277	175	330	1QFY26
155mm	\$910.54	\$454	14,400	85,000	1QFY28
HIMARS		\$71.57	5	8	4QFY25
GMLRS		\$361.08	566	1167	1QFY26
TOTAL	\$910.54M	\$1297.67M			

Source: ASA(ALT) Testimony to the HASC 2023

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After Russia’s latest invasion of Ukraine, policymakers found that the organic and commercial DMIB could not ramp up quickly to surge production of munitions even when funds were abundant. This ecosystem is hyper-efficient with a small footprint.

Given the many elements that go into producing munitions, e.g., the shell/projectile, fuse, energetics/explosives, and charges, etc. and the work done conjointly by government and industry, there are many bottlenecks in manufacturing that create long production timelines even when the intent is to produce at a faster pace.

The ASA(ALT)’s brief to the House Armed Services Committee revealed the state of the DMIB’s ability to replenish munition stockpiles. The assessment reflected three decades of underutilized infrastructure, outdated facilities layouts and machining, reduced workforces, unmappable supply chains, and a growing reliance on foreign sources of materials—all contributing to long production timelines. Given the multitude of issues, an infusion of cash is important but still has limited effect, absent increased production capacity and the workforce to run that infrastructure. On average, an 80% increase in investments today would yield 2.5 times the monthly production rate in 2.5 years—still a significant delay for supplies needed now.

While the Army is seeking more multi-year contract authority, appropriators in Congress have been reluctant to approve them, despite standing authorization language that allows for it. This leaves Service acquisition executives negotiating contracts one year at a time, in many cases. The result is a commercial DMIB sector that will not offer discounts because it is disincentivized to take proactive steps, such as updating facilities or hiring and training more workers.

While contracting officers are increasingly trying to use undefinitized contract actions (UCAs) to get production underway quickly, these agreements mostly allow industry to start work and determine the details later. Industry is increasingly disincentivized to agree to UCAs because audits after the fact often disallow many different types of costs incurred. Without a more concerted effort to change the approach, the Army will continue to experience unnecessarily long production timelines.



There are many other factors found in both the OIB and DMIB that contribute to production delays for munitions. These include environmental policy and regulatory rules, fiduciary and contracting regulations not designed to support rapid production rates, single sources of supply for one item, difficulty in qualifying second or third vendors, limited ability for new suppliers to enter the munitions market, requalification and recertification when lines stop then start up again, foreign sources of critical supplies such as rare earth materials and explosives, aging facilities lacking robotics and other advanced manufacturing, and the difficulty of incorporating advanced energetics into new or existing weapons systems.

Munitions work is scientifically rigorous, complex, and dangerous. The workforce takes great risk and often requires a minimum level of skills and proficiency. Generally, it takes two years for an average line worker in munitions to be effective. For energetics, that timeline is extended to seven years. Additionally, the technical competency required for some munitions often resides in just one source (e.g., one recipe at one plant to create one polymer).



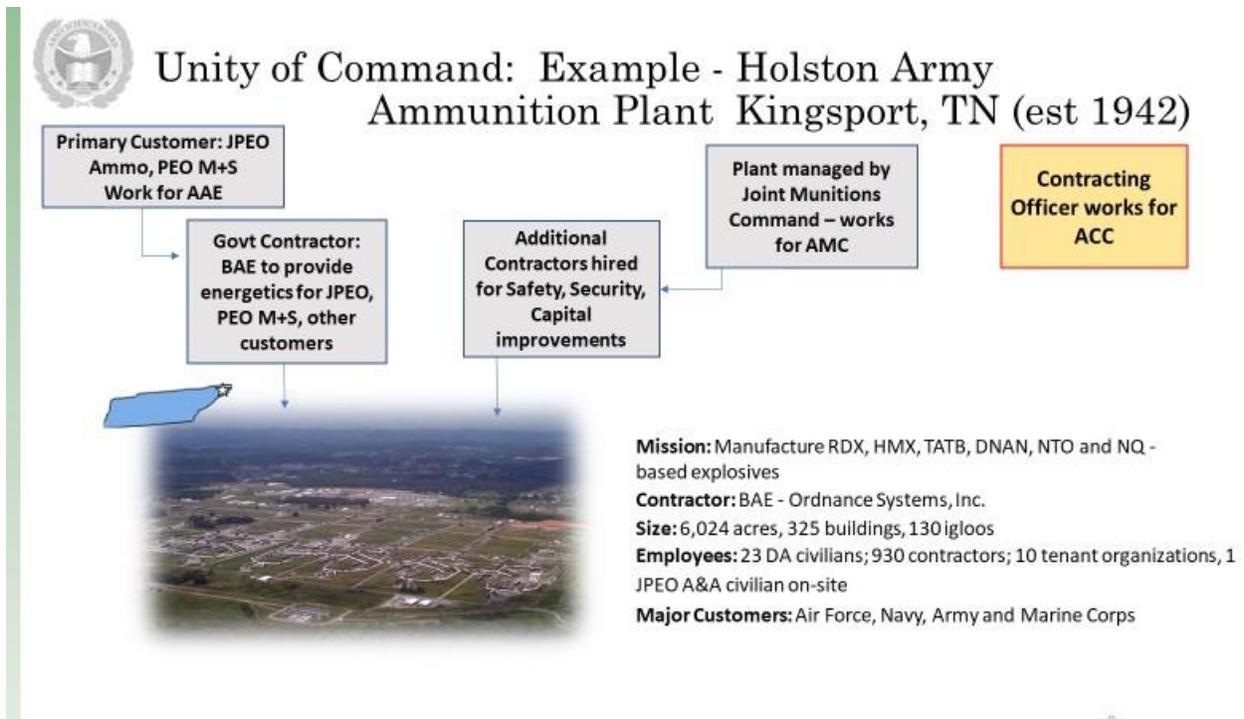
Munitions Today – Much Being Done – More Needed

- Army has initiated a 15-year modernization plan for its 80+ years-old OIB facilities
 - ~\$.5B in 2023; \$2.5B planned in FY24-28
- However, challenges remain:
 - Only a portion will be dedicated to munitions facilities
 - Investments are focused on increasing capacity today but may fail to address future needs (i.e., long lead items)
 - No risk mitigation plans exist for stockpiling critical materials or developing alternate sources of materials, components and production
 - Well over 100 single points of failure throughout the supply chain
 - Continued reliance on foreign sources of key raw materials and energetics
 - Wartime requirements are expanding and may be greater than the new TMR indicates
 - Indo-PACOM wargame results strongly imply that – even after this considerable investment – the Army may be well short of munitions in the future, with remaining concerns about the industrial base’s ability to surge.

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To date, the Army has undertaken significant efforts to increase production and invest in the modernization of the OIB. However, it is unclear whether these efforts are enough to meet future requirements. For example, the Army’s Ammunition Plant Modernization Strategy recently briefed to Congress lists very similar, aspirational objectives to those presented in 2010. Additionally, many of the initiatives underway focus on replenishing the munitions provided to Ukraine and increasing the output of existing production lines—production lines that are outdated themselves. The study team notes that more would need to be done to be prepared for the replenishment of different types of munitions that might be used in the INDOPACOM theater of operations and to fully modernize facilities to yield higher volumes more quickly. Wargaming against China, as highlighted by a recently unclassified CSIS wargame, has found that the U.S. may expend key munitions stocks in a very short time period. Whether the DMIB can backfill these expenditures at the speed and scale of peer-on-peer warfare remains to be determined.

The study team was asked by some Army stakeholders to look at individual munitions plant operations and assess their performance. That was out of scope for this study, but it would be a worthwhile effort. To conduct an adequate assessment of risk associated with this production model, any future studies should include an examination of the first, second, and third tier companies in the supply chain, many of which are single points of failure.



One of the factors contributing to a lack of senior leaders' knowledge about the frailty of the munitions industrial base is a rather convoluted chain of command. Using Holston Army Ammunition Plant as an example, two Program Executive Officers (PEOs) provide requirements at the facility and both report separately to the Army Acquisition Executive (AAE). Changes in demand quantities by either PEO directly affect the supply of energetics to the other PEO. The government contractor, BAE Systems, must respond to both PEOs and react to any changes, which may cause the costs of operations to fluctuate. For example, PEO Missiles and Space (PEO M&S) has a requirement to produce more nitrocellulose product for the AGR-20 Advanced Precision Kill Weapon System (APKWS) than currently needed, because the production of more nitrocellulose keeps the overall costs of operations down for both PEOs. This creates a higher burden on PEO M&S because it carries a higher portion of the overhead costs associated with nitrocellulose. Worse, if the decision is made to produce fewer APKWS rockets, it will drive up costs for nitrocellulose overall and negatively affect JPEO A&A. The Study team learned that such decisions are typically made at the PEO level with little visibility and coordination at higher headquarters, thereby preventing the advantages of fully coordinating "corporate" assets and overhead costs.

A third government entity, the Joint Munitions Command (JMC) oversees the Holston facility. In this role, the JMC Commander has the responsibility for the safety and security of the plant and reports to Army Material Command (AMC), a separate four-star command. Potential conflicts arise any time the Army wants to improve facilities, such as a capital improvement, a safety upgrade, etc. As such, it would take a committee of the JPEO A&A, PEO M&S, BAE, JMC, likely at least one Army Contracting Command (ACC) contracting officer, and other stakeholders to negotiate and work out the details for any such improvement. Today, this structure works largely

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due to the quality of the personnel in those key positions and their ability to work together. If designed from scratch, it is unlikely that the Army would create these multiple chains of command.

The study team met with several industry partners, a majority of whom expressed frustration with the contracting process, particularly regarding the delays associated with getting munitions development projects under contract. In one case, an industry representative cited a 9-month delay in getting an undefinitized contract in place. Very likely, this is a result of the highly restrictive regulations in the FAR/DFAR, but the study team did not investigate further, as it was outside the scope of the TOR. Even when granted waivers by Congress to these requirements (e.g., in the 2023 National Defense Authorization Act (NDAA)), industry representatives relayed Army contracting officers were slow to adopt them. Interviews with multiple PEOs and former PEOs revealed a common belief that the system would work better if the contracting officers were more closely aligned with PEO objectives versus having their responsibilities aligned with the Army Contracting Command (which also reports to Army Material Command).

Separate from the ASA(ALT), requirements generation for munitions currently consists of ongoing, diverse, piecemeal efforts to improve selected munitions performance. Responsibilities for requirements generation fall on the Army Futures Command's (AFC's) Cross Functional Teams (CFT), including Long-Range Precision Fires and Next-Generation Combat Vehicles. Among these entities, there is no overall strategy for efforts such as developing munitions requirements, improving lethality, or reducing munition size while retaining the same effects. The Study team recognizes the requirements generation responsibility lies across a number of organizations and should therefore have its own CFT or Tiger Team (TT) established to do two things:

1. Review the current threat and current innovations available in the S&T community. From that assessment, assist with the prioritization of energetics based on the effects that the CFT/TT identifies as future requirements.
2. Recommend an enduring structure or responsibility for munitions requirements be assigned, such as a center of excellence (COE), or a commandant, or a permanent CFT.

FINDINGS

Based upon the data gathered, the study team made a number of findings that highlight issues affecting surge capacity in the DMIB.



Current Army Efforts Related to Munitions Production: Findings (1 of 3)

Munitions Requirements—Formal processes are in place, but Army Sr. leaders have no visibility of tradeoffs and risks

- Requirements=Go to War + Training Rounds + **Testing Reqts** - Left over stocks + Judgment
 - FMS is not considered in the Army's Requirements Determination Process
- Requirements have to compete in the equipping (EE) PEG for modernization \$ and are **historically capped or cut** to pay other bills under the assumption the DIB can surge.
- No requirement to develop a **risk mitigation plan** when \$ are cut.
- No one entity looks at the future of munitions to set requirements for desired future effects (for example, greater lethality in the same size container) driving S+T candidates into prototype phases

Governance—There is no single authority/responsible official to oversee end-to-end Army quantity and lethality requirements and programs. For example, the SMCA authorities don't cover all types of munitions (among other things):

- Defining minimum sustaining rates
- Investing to eliminate single points of failure (ie material stockpiles, or alternative sources)
- Adjudicating between JPEO Ammo and PEO Missiles and Space, Joint Munitions Command

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MUNITIONS REQUIREMENTS

Munitions requirements are determined by the Army's Total Munitions Requirement (TMR) process that is informed by Army analysis of munitions requirements to meet the demands of relevant Defense Planning Scenarios, training and testing requirements, ongoing operational demands, and other considerations such as war reserve management. The Army's analysis is subject to review and approval by the Office of the Secretary of Defense (OSD). Funding of that approved requirement then competes within the Army's programming process under the Army Deputy Chief of Staff (DCS) for Programs (G-8). Munitions requirements, like other requirements, are subject to tradeoffs based on guidance from Congress, the Office of Management and Budget, OSD, available resources, and senior leader priorities.

Since the end of the Cold War, defense planning scenarios and underlying assumptions were anchored in contemporary experience. Pacing scenarios were limited by resource-driven assumptions and force caps, at times resulting in outcomes assessed to produce a stalemate in the relevant scenarios. Munitions assumptions increasingly reflected the low rates of expenditure seen during Operations Desert Storm and Iraqi Freedom. They also adopted an over-

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reliance on under-resourced, preferred munitions and an unproven capacity by the DMIB to surge production.

In hindsight, these assumptions proved lacking. Over the past two decades, wargames often assumed preferred munitions and SAP/STO capabilities would result in the defeat of near peer adversaries. Among others, U.S. Air Force wargames against China found conventional and preferred munition use and SAP/STO employment, while effective, were inadequate to resolve shortfalls in preferred and other conventional munitions, given the projected speed and scale of the conflict.

Similarly, 2017 planning in anticipation of possible conflict in Korea exposed these issues as they specifically applied to the Guided Multiple Launch Rocket System (GMLRS). Ammunition shortfalls and the DMIB's inability to reduce the shortfalls gained attention at senior levels in DoD but remained unresolved as the crisis subsided. The timelines and costs to resolve today's issues—three years and several hundred million dollars—are similar to those the Army had previously identified to resolve the Korea-scenario GMLRS requirements in 2017.

The U.S. support of Ukraine and recent wargames on China's invasion of Taiwan show that munitions stockpiles and DMIB capacity are inadequate to meet demand. China-specific classified and unclassified wargames found that stocks of precision and standoff weapons were expended in as little as a few days. China's dense anti-access/area denial (A2AD) capabilities attrited forward supply and frustrated or prevented resupply of forward forces. The DMIB capacity proved incapable of responding at the speed and scale of peer-on-peer war.

Deterring and, if necessary, fighting a conflict in the Indo-Pacific will require significant stockpiles of all munitions before a conflict begins. Meeting the Army's current, higher, draft TMR will ensure the Army's necessary capacity is at hand to commence hostilities. The study team requested an analysis of the adequacy of Army stocks to determine whether or not they can accomplish the wartime missions given the need to backfill Presidential Drawdown Authority munitions used to support the war in Ukraine, sustain continued conflict there, and fulfill the TMR while maintaining the capacity to meet the demands of an extended conflict. That analysis has yet to be completed at the time of this report. Without that analysis, it is unclear whether the Army's current and planned investments are adequate to meet the demands of the emerging security environment.

While complete analyses have yet to be accomplished, the study team finds that, under current conditions in the OIB and DMIB, identified munitions shortfalls cannot be resolved by a production surge in the midst of conflict.

GOVERNANCE

The U.S. Army's munitions requirements, resourcing, and production processes lack a centralized authority. They operate through various agencies, departments, and stakeholders, each with their own responsibilities and decision-making powers. While this approach allows for

specialization and flexibility in addressing specific needs, it can create challenges in terms of coordination, resource allocation, risk, and strategic alignment. As mentioned above, the Army DCS for Operations, Plans and Training (G-3/5/7) established the TMR. Once established, the munitions account has been the bill payer both for the Army and for OSD during budget reviews. These resourcing cuts appear not to have been visible to senior leaders, nor have they triggered the establishment of a risk management plan.

This governance issue acutely presents itself at the enterprise or corporate level. The ASA(ALT) has oversight for most aspects of the munitions enterprise, minus requirements generation. However, on a routine basis, much of the management functions have been delegated to the JPEO A&A as the SMCA. The SMCA authorities are limited to conventional munitions and might not be positioned to have a corporate perspective or affect the outcomes of the various interrelated requirements, resourcing, facilities, and industrial base matters or their implications on each other.

The absence of a single authority overseeing end-to-end munitions requirements, resourcing, and production introduces several implications and challenges.

- Coordination and synchronization among different stakeholders become more complex, potentially leading to inefficiencies, redundancies, and misaligned priorities. Moreover, the lack of a unified decision-making body hinders rapid responses to emerging threats or changing operational demands, causing delays in procurement or production of critical and time sensitive munitions.
- With multiple authorities involved, ensuring consistent and effective risk assessment and mitigation strategies across the entire munition's lifecycle becomes more complex. This could potentially compromise safety standards, quality control, and overall risk management practices. There is no requirement to develop an Army-level risk mitigation plan when dollars are reduced in munitions accounts.



Industry practices, concerns, and constraints: Findings (2 of 3)

Sustainable Procurement—Industry requirements to build and sustain surge capabilities

- Multiyear contracts with increased caps (>\$500M) and minimum sustaining rates would incentivize industry investment
- Reduce/mitigate single **points of failure** (e.g., energetics the best example)
- **S&T** and **R&D** leveraged across the complex to reduce reliance on foreign sources of raw materials/components

Capital Investment—Decades long signal from the U.S. Government to industry: put cost control and efficiency above all else.

- Major investments underway, however, investments needed to bridge the valley of death. For example, no PM is incentivized to try new energetics in their programs (assumes too much risk).



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The Army's ability to meet surge munitions production is an important consideration for national defense. Capital investment in munitions production can be influenced by various factors, including government policies and budget priorities. Without sustained procurement of munitions and investment in new munitions programs, the Army is not transmitting a reliable demand signal on which industry can plan and operate.

While cost control and efficiency have been emphasized by successive government administrations, it is important to note that the defense sector also faces unique challenges. The defense industry must strike a delicate balance between cost-effectiveness and ensuring an adequate supply of munitions to meet operational demands.

Budgetary constraints and the need to allocate resources efficiently can sometimes impact the capital investment in munitions production. The government strives to optimize defense spending and will prioritize investments in such areas as research and development (R&D), modernization, and advanced technologies, priorities aimed at maintaining a technologically superior and agile military force.

However, it is essential to ensure that production capacity and surge requirements of munitions are also adequately addressed. The government periodically reassesses defense needs and adjusts budget allocations accordingly. In times of increased demand or contingency operations, the government may take measures to enhance munitions production capabilities or explore partnerships with the private sector to meet surge requirements. Multi-year contracts with

increased caps and minimum production sustainment rates would incentivize private industry investment.

Efforts are made to strike a balance between cost control, efficiency, and the readiness of the Army. The government continues to collaborate with industry stakeholders to identify areas for improvement and address any gaps in munitions production, recognizing the critical importance of maintaining a robust and responsive defense infrastructure.

One of the assumptions made by the study team was that CONUS will not be a sanctuary in a conflict with a peer adversary. Single points of major defense production capabilities carry great risk. Several areas, such as energetics production (a major component in Army and Joint munitions production) and nitrocellulose production are single points of failure and require immediate attention.

Both COVID and the Russia-Ukraine conflict have exposed the fragility of the supply chain. This is evident in many production capabilities and appears in U.S. munitions production. Both S&T and R&D investments must prioritize efforts to reduce foreign sources of raw materials and components

New energetics (i.e., formulas/research) are being developed in the laboratory, however, few Army PEOs or PMs are willing to risk their program's success on a potentially transformative but unproven capability.



Current Army Efforts Related to Munitions Production: Findings (3 of 3)

Contracting:

- **Industry** – uniformly complained of **slowness** of contracting in **all cases**. Investment decisions were delayed by contracts. Small business complained of slowness to respond to inflation concerns and that they were being squeezed by IDIQ contracts
- Contracting personnel's incentives do **not** align with their customers (e.g., compliance is paramount.....savings over speed, no reward for going fast). Industry provided multiple examples of contracting delays and the repercussions on investment decisions
- Contracting personnel cite complexity of the **FAR/DFAR** and efficiencies/ability to call for reinforcements

Other ideas:

- We are making munitions now that are likely going to be used by foreign nation(s) in the near term. Do we need to rely on the more **expensive** and **time-consuming** processes and components developed for US Munitions that require safeguards & redundancies as they may sit on the shelf for decades? (backup slide)
- Senior leader visibility of munitions decisions, risks and ramifications is required. Ideas discussed included tracking tools, a new PEG for Ammunition, or this could be accomplished by the single munitions responsible person reporting to the ASAALT as recommended on slide 11

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The study team noted challenges with the speed of Army contracting actions according to both large and small defense contractors. Small businesses are being squeezed by fixed price contracts, inflation, and ever-changing, post-COVID workforce demands. The Army's contracting personnel point to the complexity of acquisition regulations and the importance of complying with statutes and regulations. It is also possible that the incentives for Army contracting personnel may not align with the needs and expectations of their customers (i.e., PEOs/PMs). Streamlining processes and finding ways to balance compliance with efficiency could potentially address these concerns.

Several types of Army munitions have seen high usage and demand rates in the Ukraine. As a result, the ASA(ALT) established a special contracting office for high visibility munitions receiving Congressional resource plus-ups. This was an ad hoc organization established for a short duration to address a specific problem. The establishment of this organization underscores the fact that "business as usual" contracting processes do not produce the desired results when speed is of the essence.

A Cross Functional Team (CFT) or tiger team for Munitions may be a way to bring together leadership from contracting, acquisition, readiness, requirements, resourcing and legal. The Army should consider the appropriate level of authority to enable the team to make decisions that are compliant with statute while speeding required munitions to the appropriate Combatant Commanders and/or Allied or Partner Nations.

OTHER IDEAS

The Army excels in making munitions that have long shelf lives to enable lot management and service life inspections (munitions with batteries are a prime example). The question should be addressed: if the munition is intended to be fired within the next year, does it require a 20-year battery life? Can some of the expensive and time-consuming processes used for U.S. munitions be waived in order to get the ammunition to the point of need more quickly and less expensively? The Army can develop alternate processes that save time and resources on attritable munitions.

The study team observed that important decisions affecting munitions production were made outside the cognizance of senior leaders. It would be beneficial to develop a tracking tool that enables decision-makers to track and correlate resourcing to projected need, to production, to readiness. Alternately, the Army could establish a separate Army Program Evaluation Group (PEG) for munitions. In the past, munitions were frequently used as bill payers in budget drills, so this new PEG would also assist the Army as the Joint Munitions Executive Agent in “priority” discussions with the other services, and in OSD budget drills.

The Army should also look at increasing the number of high dollar munitions used in training Soldiers. This could help establish a consistent demand signal for defense industry partners and could help in retention rates (or recruiting) by providing Soldiers with training with their go-to-war weapon systems/munitions.

Improved utilization of modern production planning and inventory policies in industry can improve surge capability. The concepts of “Safety Stock” and material requirements planning (MRP) worksheets can further improve the supply chain management. Presentation of these techniques can be used to inform senior management of the consequences of decisions.

RECOMMENDATIONS

The study team developed recommendations, actionable in the short term, to address observed gaps and shortfalls.



Recommendations for Near Term Actions

1. Create/elevate a **single authority** to plan, oversee, and mitigate implications of munitions resourcing, capital investments, industrial base concerns, etc. [ASA\(ALT\) \(AAE\)](#)
2. Create a CFT or tiger team to examine **requirements** for new munitions and energetics [SecArmy/CSA](#)
3. Examine initiatives to **better align the incentives** of organizations supporting this mission [ASA\(ALT\)/AAE](#)
4. Analyze **future strategic munitions needs** to fill the gap in munitions (and their components) for future peer fight(s). [G-3/5/7](#)
5. Consider cheaper **attributable munitions** [ASA\(ALT\)/AFC](#)
6. Identify and prioritize munitions and **long lead items** necessary to surge for future needs [ASA\(ALT\): Single Authority](#)
7. Present consistent **demand signals to industry** to enable production capability: [ASA\(ALT\) & G8](#)
 - minimum sustainment rates
 - multiyear procurement authority w/increased caps (>\$500M)-requires OSD/Congress
8. Make **investments** to develop new materials, increase production capacity, and reduce foreign dependency: [ASA\(ALT\) & AFC](#)
 - Examine and recommend immediate investments in programs to bridge to new energetics
 - Initiate a flexible pilot plant line to develop explosive synthesis and provide additional capacity

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1. SECARMY/CSA create a CFT or tiger team to examine requirements for new munitions and energetics.

2. ASA(ALT)(AAE) create/elevate a single authority to plan, oversee, and mitigate implications of munitions resourcing, capital investments, industrial base concerns, etc.

To address the challenges associated with the lack of a single authority, the U.S. Army could explore several options. One is to establish a centralized authority responsible for holistic oversight of munitions production matters from requirements to resources to procurement. Specifically, this would require retaining some of the SMCA authorities at the ASA(ALT) level (i.e., elevating this from the JPEO A&A), enhancing those responsibilities, and assigning someone on the ASA(ALT) staff to manage these duties, to include:

- Oversight of S&T for munitions
- Oversight of resourcing efforts
- Capital investment decisions at OIB facilities
- Input and coordination with a requirements CFT or TT
- Establishment of minimum sustaining rates for key munitions

- Advocacy for multiyear contracts as appropriate
- Establishment of mitigation plans when resources are inadequate
- Monitoring and mitigating industrial base considerations (i.e., cold production lines, single sources, foreign suppliers)
- Coordination and engagement with other Services and OSD entities assigned these and similar responsibilities (for example, OSD's Joint Production Accelerator Cell)

This authority would facilitate senior leader visibility, consolidate decision-making, streamline processes, and ensure strategic alignment across all stakeholders. Such an authority would enhance coordination, resource optimization, and risk management while providing a comprehensive and systemic view of munitions production. The AAE does not have the capacity to oversee all the diverse requirements of the munition's ecosystem. That role should be performed by someone with an enterprise view in the Pentagon, not a PEO whose efforts might be better focused on the near-term tactical focus on program execution.

3. Examine initiatives to better align the incentives of organizations supporting this mission ASA(ALT)/AAE.

The Army should look to strengthening interagency collaborations and establishing clearer lines of communications and accountability among existing DMIB entities. This would require improved coordination mechanisms, standardized processes, and information sharing protocols. By enhancing cooperation and synergy among different stakeholders, the Army could mitigate some of the challenges posed by the decentralized approach.

Another step to improve command and control of the DMIB enterprise would be to examine the need for multiple PEOs in the munitions field. PEO Missiles and Space is the only PEO that both builds their systems (shooters) and their munitions. Common inputs to both missiles and conventional munitions (e.g., energetics, nitrocellulose) impact both PEOs responsible for munitions and multiple programs. One entity in charge could manage this entire enterprise. Moreover, the study team found little value added for a third entity—the Joint Munitions Command—to run the security and safety of GOCO installations. This simply involves another party to negotiate with in the event of capital improvements or safety efforts impacting production.

A final consideration for unity of command involves the contracting process. Both industry partners and current and former PEOs expressed frustration with the slowness of contracting actions. The latter were interested in a better alignment of incentives for the contracting officers they work with. The study team did not have the time nor mandate to examine the problem in depth, but the slowness appears to be driven by the requirements inherent in the FAR/DFARS and exacerbated by contracting officer's alignment with ACC rather than the PEOs. A parallel to this might be found in Army Training and Doctrine Command (TRADOC), where the Branch Schools have the responsibility for developing doctrine and training both enlisted and officer personnel. They establish the doctrine and standards. Once trained, the Soldiers are then assigned to units. Similarly, ACC could be responsible for the training of contracting personnel

and compliance with standards, but then contracting personnel would be assigned to the PEOs. The study team also recommends a follow-on study be conducted to examine ways that the FAR/DFARS can be streamlined to enhance speed of contracting and flexibility.

4. DCS G-3/5/7 analyze future strategic munitions needs to fill the gap in munitions (and their components) for future peer fight(s).

Focusing on the shortage of munitions and the delays in accelerating production, data gathered indicates future munitions requirements may well be underestimated for a peer fight. This would, once again, necessitate a significant ramp up in munitions production.

5. ASA(ALT) and AFC consider cheaper attritable munitions.

U.S. Army munitions are manufactured with safety and endurance as vital parameters. Munitions are built with long-lasting components because they may sit in storage for a number of years. However, many munitions are currently expended in a much shorter period of time—either to meet annual training requirements or for FMS, where the ammunition will be fired rapidly. The study team believes several munition types with extended life batteries or tin whisker¹ mitigation could be manufactured faster and cheaper if they were not built with extended shelf-life requirements. For example, the Army may be able to drive down the price of expensive missiles and rockets that are used for training, freeing up resources for other purposes (see Appendix E for additional details).

6. ASA(ALT) identify and prioritize munitions and long lead items necessary to surge for future needs.

To overcome the delays in ramping up production, establish long lead-time items for selected munitions. A large stockpile of munitions is expensive to build and subject to extensive reliability testing over time (also an expensive undertaking). To mitigate this, the Army should seek approval for the purchase of long lead items for the most important and complex munitions. The long lead time supplies could be used to feed ongoing production on a first-in, first-out basis to ensure the items do not become outdated. The advanced purchasing of long lead items is not a cure all in and of itself, but in spot checking several different munition types, the study team learned it may reduce production times by up to 30%.

¹ Tin whiskers are electrically conductive, crystalline structures of tin that sometimes grow from surfaces where tin (especially electroplated tin) is used as a final finish. Tin whiskers have been observed to grow to lengths of several millimeters (mm) and in rare instances to lengths in excess of 10 mm. Numerous electronic system failures have been attributed to short circuits caused by tin whiskers that bridge closely spaced circuit elements maintained at different electrical potentials. (Source: <https://nepp.nasa.gov/whisker/background/>)

7. ASA(ALT) and DCS G-8 present consistent demand signals to industry to enable production capability:

- **minimum sustainment rates**
- **multiyear procurement authority w/increased caps (>\$500M)-requires OSD/Congress**

Establish minimum sustaining rates and multiyear contracts for select munitions. The biggest challenge in a ramp up is starting up a line once it has been stopped. Workers must be trained, and long lead items procured. The line itself has to be validated and quality defects in production are much more likely at a start-up. This combination of minimum sustaining rates and select multi-year contracts should contribute to a much more resilient industry by smoothing out erratic and unpredictable purchases into a more reliable procurement plan over several years.

8. ASA(ALT) and AFC make investments to develop new materials, increase production capacity, and reduce foreign dependency:

- **Examine and recommend immediate investments in programs to bridge to new energetics**
- **Initiate a flexible pilot plant line to develop explosive synthesis and provide additional capacity**

The study team did not have the time to investigate GOCO plants and facilities, but it was clear that they are almost completely unique and reside at the end of a series of fragile supply chains. However, the study team recommends that the Army establishes a pilot line for energetics at Picatinny Arsenal. This pilot line would provide geographic dispersion from the Holston Army Depot and provide a location where new energetics solutions and prototypes could be built and tested. Additionally, we believe, if built correctly, the facility could be a testing ground for advanced manufacturing techniques.

Additional investment priorities include two key projects to enhance conventional and missile effectiveness. Those details, as well as the details on the pilot facility, are included in the controlled annex to this report (see Appendix E for additional details).

The study team found that many S&T products were not being driven over the “Valley of Death.” That is, they remained in S&T status rather than being built out as prototypes and included in new weapons. Several factors contributed to this state of affairs. First, the Study team could not identify an office charged with overall future munitions requirements, a separate effort from the DCS G-3’s responsibility for determining annual munitions expenditures. As mentioned, AFC has identified specific requirements for a few specific systems. However, no one is taking a wholistic approach. As a result, improved energetics may be identified in S&T, but because of the lack of system requirements for them, they are not carried through to procurement (e.g., a requirement to enhance explosive effects for a given munitions diameter, or length). No PM would risk their programs on the development of unproven technologies, so they rely on the previously developed solutions. The study team believes that a tiger team could be established to investigate the situation, develop near-term requirements, and plan a path forward (see Appendix E for additional details).



Recommendations for Further Study

Consider follow-on studies:

- The GOCO model, its current effectiveness, and options for the future
- Adoption of advanced manufacturing processes
- An in-depth examination of the commercial supply chain
- Authorities and policies to enhance rapid and responsive contracting
- Review of the FAR/DFARS for suggestions to simplify and accelerate contracting options



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The study team identified a number of areas for further investigation and study, either by the ASB or some other entity. These include:

1. The GOCO Enterprise – This topic was reviewed by the McKinsey group about 5 years ago. The environment was completely different then, and much has changed. It may be time to have another review to determine the best methods for securing the munitions enterprise in the future and especially in the light of a potential peer competitor.
2. Investments in a Pilot Line Facility – This effort would investigate new energetics and manufacturing techniques. There are a number of different initiatives and a complete review coupled with prioritization may prove helpful. In addition, given the work being done in advanced manufacturing techniques and procedures, the pilot line would be a superb venue for experimenting with these cutting-edge techniques. Those offering the most promise could be validated and shared with other GOCO facilities (see Appendix E for additional details on energetics investments).
3. Contracting – The near unanimous frustration with the contracting enterprise warrants a look at the complexity of the FAR/DFAR. Numerous constraints and requirements conspire to slow contracting at every step. The requirements also contribute to a reward system that underwrites slow and methodical efforts. These efforts often do not align with a PM's need to commit funding (or face losing it) or to go fast, even when Congress has authorized and encouraged reform, as it has in the FY23 NDAA. Another indicator that this area deserves a deeper look is that the ASA(ALT) set up a special cell to assist in

improving contracting timelines. A study to investigate faster methods and procedures, and potentially better alignment of outcomes, is needed.

4. The Munitions Supply Chain – Senior leaders should have better fidelity of the munitions supply chain, which is complex, opaque, and dependent upon vulnerable foreign sourced materials. An in-depth examination on one or more aspects—e.g., chip vulnerability, would underscore the need to reduce dependence on foreign sources of supply where practicable.

APPENDIX A – TERMS OF REFERENCE



SECRETARY OF THE ARMY
WASHINGTON

06 JUL 2023

MEMORANDUM FOR

ASSISTANT SECRETARY OF THE ARMY (ACQUISITION, LOGISTICS, AND TECHNOLOGY), 103 ARMY PENTAGON, ROOM 2E532, WASHINGTON, DC 20310-0103

DEPUTY CHIEF OF STAFF, G-8, 700 ARMY PENTAGON, WASHINGTON, DC 20310-0700

CHAIRMAN, ARMY SCIENCE BOARD, 2530 CRYSTAL DRIVE, SUITE 7098, ARLINGTON, VA 22202

SUBJECT: Terms of Reference for Army Science Board Study "Surge Capacity in the Industrial Base"

1. I request the Army Science Board (ASB) conduct a study entitled, "Surge Capacity in the Industrial Base." The purpose of the study is to provide insights and recommendations to build resiliency and depth in the industrial base of 2025. The study will begin with a review of governance, policies, procedures, and initiatives that either enable or hinder the surge production of munitions.

2. The war in Ukraine, combined with the effects of the COVID-19 pandemic on the global work force, have exposed increasingly brittle supply chains supporting national security capabilities. As the Department of Defense (DoD) requested the defense industrial base to ramp up production of munitions and foreign military sale items to support Ukraine, industry responded with long lead times, single points of failure, and worrying dependencies on fragile foreign sources of supply. Concerns have arisen over whether and how these challenges might also impact operations in the INDOPACOM theater. The study will focus primarily on the requirements for production of select munitions and a near-term set of actions that would strengthen resiliency and depth in the industrial base by 2025. Specifically, the study team's tasks shall include, but not be limited to, the following:

- a. Identify and understand current Army efforts and plans related to munitions production.
- b. Examine industry practices, concerns, and constraints.
- c. Provide discrete recommendations for near-term actions to facilitate improved surge capacity by 2025.
- d. Determine whether there are new or updated governance, policy, procedures, and initiatives to enable the Army's and industry's ability to surge in response to a crisis.

SUBJECT: Terms of Reference for Army Science Board Study "Surge Capacity in the Industrial Base"

3. The Director of Program Analysis and Evaluation within the office of the Deputy Chief of Staff, G-8, and the Deputy Assistant Secretary of the Army (Strategy and Acquisition Reform) within the office of the Assistant Secretary of the Army (Acquisition, Logistics, and Technology) will co-sponsor this effort and assist the study team. Support will include providing a government representative, grade O-5 (or civilian equivalent), to act as an Alternate Designated Federal Officer for the study and providing access to classified information and other resources as needed.

4. The study team's analysis will leverage existing work and the scope will be tailored to enable actionable results in a timely fashion. A briefing with findings and recommendations will be provided by 31 May 2023, to myself and the Chief of Staff of the Army. The study will operate in accordance with the Federal Advisory Committee Act and DoD Directive 5105.4, DoD Federal Advisory Committee Management Program. It is not anticipated that this study will need to go into any particular matters regarding the meaning of the United States Code, nor will it cause any member of the study team to be placed in the position of acting as a procurement official that may constitute a conflict of interest.



Christine E. Wormuth

CF:

Chief of Staff of the Army
Under Secretary of the Army
Vice Chief of Staff of the Army
Chief Information Officer/G-6
Deputy Chief of Staff, G-2
Deputy Chief of Staff, G-3/5/7
Deputy Chief of Staff, G-4
Commander
U.S. Army Forces Command
U.S. Army Training and Doctrine Command
U.S. Army Materiel Command
U.S. Army Futures Command
U.S. Army Cadet Command
U.S. Army Recruiting Command

APPENDIX B – STUDY TEAM MEMBERS

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APPENDIX C – DATA GATHERING



Research, Data Gathering, and Analysis

Army Organizations

- Army Contracting Command
- Army Combat Capabilities Development Command
- Army Futures Command (Headquarters)
- Army G-2
- Army G-3 (Ammunition Requirements)
- Army G-4
- Army G-8
- Army G-8/Program Analysis and Evaluation
- Army Material Command
- Army Test and Evaluation Command
- Army Science Board
- Assistant Secretary of the Army/ Acquisition Logistics and Technology
 - Joint Program Executy Office Armaments and Ammunition
 - Joint Program Office Missiles and Space
 - Science and Technology
- Deputy Secretary of the Army for Defense Exports and Cooperation
- Under Secretary of the Army

Industry

- British Aerospace
- Cypress International
- General Dynamics
- Leidos
- Lewis Machine and Tool
- Northrop Grumman
- Raytheon
- Spectra

OSD Organizations

- USCYBERCOM
- Assistant Secretary of Defense for Industrial Policy

Other Organizations

- National Armaments Commission
- Heritage Foundation
- Independent Board Members
- Munitions Industrial Base Task Force
- The Hudson Institute
- White House (CHIP Act)

APPENDIX D – DISCUSSION WITH HON. GABE CAMARILLO, UNDER SECRETARY OF THE ARMY

The study team briefed Hon. Gabe Camarillo, Under Secretary of the Army (USA), on its preliminary observations and potential next steps for the Army to consider. The briefing occurred on May 30, 2023 and was attended by several members of the study team, the study chair, the study manager, and the ASB Designated Federal Officer (DFO).

The USA provided feedback and comments on the preliminary work that led the study team to collect additional data and refine its analyses. In addition, the study team provided the following responses to the USA on four specific lines of inquiry:

USA: Clarify how the study team uses the term ‘attributable munitions’ and identify good candidates that might benefit from this approach.

As used in this study, the term ‘attributable munitions’ applies to munitions that are not designed to the normal rigor and expense but still maintain the required effectiveness. Normally, U.S. munitions are built to be stockpiled for the long term, then examined, and either extended or modified to be extended for a longer storage period. Such longer storage times increase unit costs and limits munitions selection to those whose materiel performance does not diminish with age. The added cost of the long storage life builds from several factors, including corrosion prevention, aging of components and energetics, tin whiskers on electric joints, power source designs, etc. During times of rapid usage, the extra costs associated with the resources required to maintain a munition's long shelf-life/lifespan are not warranted if used within 1-2 years. A key aspect of the attributable concept is the availability of multiple sources of material to work around shortages and maintain production. An example is the explosive Amatol, which is a mixture of TNT and Ammonia Nitrate (a cheap fertilizer) that was used to great effect during both world wars but has a very limited shelf life.

Note there may well be considerable start up costs to doing this, for qualifying the ammunition, and ensuring the safety of the process for those that would be used by a certain wear out date.

Missile systems are likely candidates for these attributable munitions given their complexity. The AGM-179 Joint Air-to-Ground Missile (JAGM) and the AGM-114 Hellfire would be the study team's first recommended models, followed by FIM-92 Stinger man-portable air-defense system (MANPADS), the Guided Multiple Launch Rocket System (GMLRS), and the BGM-71 Tube-launched, Optically tracked, Wire-guided (TOW) missile.

At the component level, a medium caliber munition uses an expensive liquid reserve battery that has a long shelf life. Unfortunately, the production of these batteries can only meet 10% - 30% of the wartime use. Using commercial batteries with a limited shelf life can fulfill wartime requirements, while the liquid reserve batteries can be used for reserves. This could be applicable for any similar munition.

Currently, JPEO A&A at Picatinny Arsenal is experimenting with an attritable 155mm design.

USA: Identify the right munitions stakeholder strategy for requirements. Do we need a permanent solution or a temporary one? Should this involve another CFT or can an existing one be tasked?

The study recommends two immediate actions regarding command and control:

- A single authority for munitions be assigned, reporting to the ASA(ALT), to assist in the SMCA role and to oversee and advise on capital investments, S&T investments, and new manufacturing advances.
- An OPR to monitor funding tradeoffs and employ risk mitigation plans.

In addition, the study team believes a CFT should establish munitions/energetics/effects requirements to provide a push for new energetic solutions across the “Valley of Death.” On the other side, a lethality TT should be established to pull solutions across the “Valley of Death” by providing threat based requirements and understanding the art of the possible with future technology.

USA: Is there a priority the Army should apply to next generation energetics?

The Office of the Under Secretary of Defense for Research and Engineering (USD(R&E)) published the National Energetics Plan in June of 2023. The study team noted the following:

- Over the last several decades...the prominent role of energetic materials in providing effects has been, in large measure, taken for granted, and the energetic materials themselves have been undervalued, commoditized, and minimally innovated.
- Insufficient coordination and misaligned timelines between the S&T (Budget Activities 1, 2, and 3) and the program office (acquisition) communities stifle the transition of advanced energetics to acquisition programs and operational use.
- Establish two agile specialty chemical synthesis pilot-scale plants, one refining pilot-scale plant to process raw ingredients into feed stocks, and one manufacturing research and development pilot plant.

The study team recommended the establishment of a pilot line at Picatinny Arsenal to serve as a location for the development of prototype energetic solutions. Picatinny adds a geographically diverse location to the energetics facility at Holston and a back up effort if needed. The DOD lacks this kind of diversity now, but it has historically used pilot lines for production in prior surges.

Surge Capacity in the Defense Munitions Industrial Base

Regardless of location, the pilot line should be built to include an experimental effort for the development of advanced manufacturing techniques. These can be tested and validated at Picatinny before implementing at other GOCO facilities.

The study team's observations for prioritizing energetics technologies include the following:

- CL-20 requires further investment in order to reduce future costs, improve processing, and demonstrate in a fielded system. The material holds great promise in improving performance for a variety of systems.
- Poly Lauryl Methacrylate (pLMA) binders may be limited by future environmental regulations that limit the use of fluoridated compounds currently used in common explosive formulations. A replacement should be found prior to any regulator changes.
- Additive Energetics in the form of explosive Inks have been successfully gun-launched in a demonstration of an advanced initiation systems, which greatly improved performance. This is an example of using additive manufacturing in components where it is economically feasible.
- Attritable Energetics should be planned out and developed before surge requirements.
- 3, 4-Dinitropyrazole (DNP) or other based meltable as a potential replacement for TNT.

USA: Review the AS(AALT) strategy for munitions FMS and determine how it might change the demand signal for munitions in the future.

The study team did not have the time to conduct a thorough review of the business case but recommended the ASA(ALT) work with AFC to consider development of cheaper, attritable munitions for FMS to steady the demand signal.

APPENDIX F. Controlled Annex: Near-Term Investment in S&T

The controlled annex provides additional information supporting two of the study team's recommendations:

5. ASA(ALT) and AFC Consider cheaper attritable munitions.

8. ASA(ALT) & AFC Make investments to develop new materials, increase production capacity, and reduce foreign dependency:
 - Examine and recommend immediate investments in programs to bridge to new energetics
 - Initiate a flexible pilot plant line to develop explosive synthesis and provide additional capacity

The section on attritable munitions provides a technical definition, differentiators to traditional munitions, and examples of near-term applications.

The investment section provides background on supply chain risk reduction, historical context for pilot plants, program characteristics, justification for investment in new energetics, and suggestions on specific programs.

The annex contains controlled unclassified information (CUI).

Send requests for access to the controlled annex to:

usarmy.pentagon.hqda-asa-alt.mbx.army-science-board@army.mil



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