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Defense Industrial Base Case Study

July 24, 2020

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Graduate School of Defense Management

Naval Postgraduate School

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Abstract

This defense industrial base case study encourages critical analysis of a U.S. Department of Defense project facing typical management oversight questions regarding industrial base planning within defense acquisition. The case centers on the capability and capacity of the defense industrial base to develop and produce body armor for Army Soldiers. The case study incorporates the perspectives from key stakeholders to include commercial industry companies, congressional committees, Army senior leadership, and the program management/acquisition chain of command. Considerations include the balancing of limited resources against competing priorities, sustaining inventory for wartime readiness, managing the demand for increased capability, and balancing surge requirements with industry capacity. The case study reinforces critical thinking in uncertain environments, documents lessons learned for sound project management, and provides exposure to the complexities of public sector acquisition and body armor manufacture.

Intended Audience, Recommended Courses, and Placement

The case is widely applicable to project management (PM) professionals in both the public and private sectors. The case is suited for students concentrating in PM fundamentals or for functional experts in the PM-related fields of systems engineering, business and financial management, operations management, and logistics or supply chain management. The case is written at the graduate or executive education level. The case can be incorporated into the later stages of graduate or executive-level course curriculum and used in courses specializing in project/program management, operations/planning management, or strategic leadership.

Learning Objectives

- Develop the ability to critically analyze a project—critical thinking.
- Identify and understand key stakeholders—stakeholder engagement.

- Develop, compare, and recommend alternative strategies—resource management and decision-making.
- Identify second-order consequences of the recommended strategies—strategic management/leadership, leading change, and managing complexity.

Key Words: industrial base planning, acquisition, inventory management, congressional oversight, Defense Production Act, industry competition, and innovation

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Introduction

The U.S. Army program manager (PM) for Soldier Protection and Individual Equipment (SPIE) was wrapping up another busy week one Friday afternoon in March 2015 when her phone rang. On the other end was the Program Executive Office (PEO) congressional affairs contact officer (CACO) and the PEO public affairs officer (PAO). Both stressed that there were issues and questions centered around the body armor plates that Soldiers fit into ballistic vests, whose function it is to provide protection against fragmentation, pistol and rifle threats. The PAO was concerned about news media coverage, and the CACO was relaying a warning order to be ready to support Army leadership as they prepare for congressional hearings on the Army's portion of the President's Fiscal Year (FY) 2016 budget request. Apparently, the commercial companies who manufacture body armor had provided Congress and media an information paper painting an unacceptable situation with respect to the sustainment of a viable body armor industrial base (see Figure 1).

Well, so much for the weekend, she thought as she started to think about the documents she would need over the weekend to write information papers and prepare presentations to educate, yet again, Army senior leaders, congressional staff, and potentially congressional members on body armor plates. The PM called in her deputy to start to schedule meetings with the proper stakeholders early the following week.

These concerns jeopardized the planned Milestone C decision for approval from the milestone decision authority (the PEO Soldier for this Acquisition Category III program) to award low-rate initial production contracts for next-generation armor plate protection. The PEO had already approved the acquisition strategy (AS) for the milestone review. The AS included industrial base planning as required by DoD acquisition regulations and guidelines. The PEO now was requesting to delay the planned milestone until after the Army had addressed these new concerns from industry that were shared with Congress.

The PEO wanted to get ahead of any negative media coverage and update the AS accordingly. A substantial change of the planned milestone would affect the acquisition program baseline's cost and schedule and put the procurement funding at risk if not obligated and expended by the end of the FY.

U.S. Hard Body Armor Industry in Crisis

The Department of Defense (DoD) with the assistance of Congress has spent hundreds of millions of dollars to establish a world-leading industrial capability to design and manufacture state-of-the-art body armor plates. These plates, called Enhanced Small Arms Protective Inserts (ESAPI), are the bullet stopping technology that has saved so many lives in combat. At one point in 2007, the U.S. had seven major manufacturers of ESAPI under contract and in sustainable production. Since that time, the industrial base has consolidated as requirements have increased and standards have been tightened to a point where there are only two viable manufacturers that can meet current and potential future surge requirements for ESAPI – BAE Systems & 3M-Ceradyne. These are the only remaining companies that can produce ESAPI in an increasingly hostile battlefield environment. Both companies are on the verge of exiting the ESAPI manufacturing business primarily due to decreased demand in DoD contracting and the lack of a DoD ESAPI industrial base sustainment strategy. In the event of another major regional conflict, the potential is high for U.S. warfighters to be sent into battle with less than the best available body armor. This same situation was faced in 2003, when our forces were sent into Iraq and Afghanistan either without body armor or without the best available body armor.

The key critical impact of losing the ESAPI industry is that DoD loses the ability to surge manufacturing quickly in the event of a major regional conflict. This coupled with the lack of inventory controls and the absence of aging standards or surveillance testing protocols on current stocks is leading to a potential problem. These decisions (or lack thereof) will impact not only the primary ESAPI manufacturers, they will affect an entire supply chain of companies that supply key component parts like ceramic tiles and high molecular weight polyethylene. These sub-components are highly engineered and specific to ESAPI designs.

This has real impacts on critical manufacturing jobs in the U.S. These are skilled jobs that require training and precision. ESAPI is not just another piece of gear. It is a highly engineered, precisely manufactured, life-saving product. Every production run of ESAPI is stringently and exhaustively tested in a destructive ballistic test that verifies and validates that each ESAPI protects and functions to the most rigorous specifications. Very few items in the DoD inventory are routinely put through these types of tests.

If DoD allows the ESAPI industry to close down, it could have long-term impacts. This industry was not created overnight, and it will not be re-established overnight. Americans who cannot be easily replaced will lose their jobs. Equipment will be sold off or mothballed. Entire segments of the supply chain may be forced to abandon their support and investment in ESAPI.

Figure 1. Paper Provided to Congress from Industry (Adapted from 3M Paper, personal communication, 2015)[1]

Understanding Body Armor Procurement

Over the last two decades, the Army had greatly improved the personal protective equipment (PPE) that Soldiers wore into battle. Soldier PPE against ballistics threats primary included helmets, vests, and groin protection. Soldiers wore ballistic vests to protect the torso. Ballistic vests included layers of polymer (para-aramid or ultra-high molecular weight polyethylene [UHMWPE]) fibers woven into fabrics that provided Soldiers protection against fragmentation and handgun threats (referred to as “soft armor”). To protect against rifle threats, Soldiers inserted armor plates (referred to as “hard armor”) into sleeves or pockets in their ballistic vests. The current Army vest was the Improved Outer Tactical Vest (IOTV), which accommodated four hard armor plates—identical front and back plates and two side plates (see Figure 2). The Army had two versions of hard armor plates available to Soldiers depending on the threat. The standard issue for each deploying Soldier was two enhanced small arms protective inserts (E-SAPI) and two enhanced side ballistic inserts (E-SBI) to be used with the IOTV providing full protection. The Army also had an inventory of X-threat small arms protective inserts (X-SAPI) and X-threat side ballistic inserts (X-SBI) that offer a higher-level protection than E-SAPI and E-SBI. The Army procured hard armor plates with annual operations and maintenance (O&M) appropriations (i.e., one-year money) because plates were considered expendable items (despite also classified as critical safety items) and using O&M dollars maintained budget flexibility. The average unit procurement cost (AUPC) for E-SAPI/X-SAPI was approximately $450, and the AUPC for E-SBI/X-SBI was approximately $250. The PM maintained the technical procurement specifications for hard armor plates and managed the qualification and acceptance testing of hard armor plate contracts along with the Defense Logistics Agency (DLA), the procurement activity for sustainment buys of hard armor. The legacy hard armor plate program was in the operations and sustainment (O&S) phase of the acquisition life cycle—well past the initial Army acquisition objective of 966,000 sets of plates. For the procurement of expendable PPE, additional quantities of hard armor plates (beyond the initial Army acquisition objective) were required to replace the initially procured items as they wore out. As a result, Headquarters Department of the Army (HQDA) G-4 worked with the Tank and Automotive Command (TACOM) Organizational Clothing and Individual Equipment (OCIE) Central Management Office (CMO) to program funding annually to replace hard armor plates using sustaining program evaluation group (SS PEG) funding (jointly overseen by the HQDA G-4 and Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA[ALT]). The TACOM OCIE CMO procured Army PPE sustainment requirements through DLA Troop Support (DLA TS) contracts.

Figure 1. Hard Armor Issued to Soldiers. Adapted from Program Manager Soldier Protection and Individual Equipment (PM SPIE, personal communication, June 2014).[2]

E-SAPI and X-SAPI replaced SAPI originally worn by Soldiers in the outer tactical vests (OTVs). These hard armor plates had stringent requirements in manufacturing contracts using performance-based specifications—meaning the Army specified ballistics testing, interoperability, and interface requirements—but did not specify the processes and materials (the "how") contractors used to manufacture the plates. The use of performance-based specifications maximized competition, allowed for innovation, and protected each company's intellectual property in terms of specific materials and manufacturing processes. Each manufacturer used different materials and processes, but the hard armor plates all met the same performance requirements and were visually indistinguishable. Over time, in collaboration with researchers at the U.S. Army Research Lab and U.S. Army Natick Soldier Research, Development and Engineering Center, commercial industry had innovatively developed and manufactured higher performing hard armor plates. To meet the Army requirements/constraints for size, weight and ballistic protection, industry vendors for the development and manufacture of hard armor plates settled into an optimal mix of materials and processes.

Hard armor plates protected the Soldier's vital torso area and were therefore limited in maximum size dimensions. A trade-off existed between weight of plates and the ballistic protection they provided. Generally, heavier plates could potentially provide greater ballistic protection but they also degraded mobility and increased battlefield fatigue. Commercial industry found that the best way to meet the performance requirements had been to assemble a hard armor plate consisting of the followings layers:

- A core ceramic tile (made from either silicon carbide [SiC] or boron carbide [B_4C]) provides protection against ballistic threats and usually cracks when impacted by an incoming round.
- Behind the ceramic plate is a crack arrester (made from aluminum [Al] or titanium [Ti]), a thin sheet of metal mesh that helps maintain the integrity of the ceramic tile if cracked when impacted by a threat round.
- Behind the crack arrester are layers of armor polymer fibers weaved into thin sheets and then fused together (made of para-aramids like Kevlar© or ultra-high molecular weight polyethylenes). These layers absorb any fragmentation that makes it through the ceramic tiles and any ceramic particles from cracked tiles.
- A cloth covering is then fitted around all the layers so that plates appear visually indistinguishable.

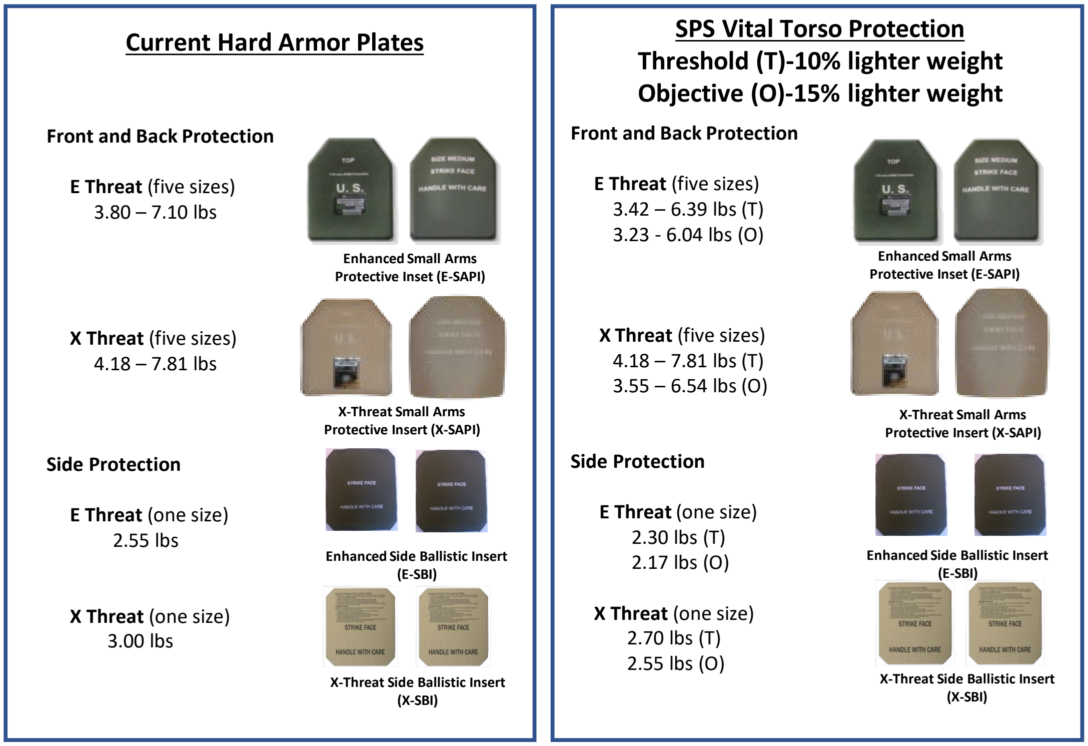
Commercial industry was given the freedom to innovate and use any combination of materials as long as the plates meet the performance requirements (primarily ballistic protection, size and weight). For example, X-SAPI and X-SBI were manufactured using SiC ceramic plates, but E-SAPI and E-SBI were manufactured with B_4C ceramic plates. Generally, B_4C is lighter but more expensive then SiC. X-SAPI and X-SBI were designed to protect against specific armor piercing threat rounds. Some armor piercing rounds induce a phase change in B_4C crystals in which they became amorphous losing structural integrity. Therefore, the higher performing (from a ballistics protection standpoint)

X-SAPI/X-SBI incorporated less expensive raw ceramic powder than the less performing E-SAPI/E-SBI. The trade-off being weight in this situation—the Army accepted the E-SAPI/E-SBI level of ballistic protection at a lower weight and higher expense. For the crack arrestor, the important derived specification requirement was to match the thermal expansion coefficient of the crack arrestor material with the thermal expansion coefficient of the ceramic material. Generally, Ti matches this requirement better even though it's more expensive and heavier than Al. Finally, the processes being used to manufacture the plates varied between commercial vendors. The ceramic tiles were made from SiC and/or B_4C powder, which is put under heat and pressure for a period to form a ceramic tile with the desired properties. Different processes (sintering or hot pressing) result in different ceramic properties resulting in varying levels of ballistic protection. The bottom line is that the hard armor plates were highly engineered, as claimed by commercial industry in Figure 1, with an optimized design to meet the stringent Army performance requirements.

In May 2013, the Army approved and funded the Soldier Protection System (SPS) program of record with a Milestone B approval to award engineering and manufacturing development contracts (PM SPIE, personal communication, May 21, 2013).[3] The SPS was the first Army PPE program that integrated the development of the five different parts of the PPE ensemble simultaneously. SPS was to provide Soldiers with an integrated, scalable, tailorable PPE ensemble with protection level equal to or greater than current levels and at a lighter weight. Figure 3 provides an overview of the SPS components.

Figure 2. Soldier Protection System Overview. Adapted from PM SPIE (personal communication, May 21, 2013).[4]

The newer hard armor plates of SPS were named vital torso protection (VTP). The Army-approved capabilities development document (CDD) contained one key performance parameter (KPP) for the VTP: provide equivalent ballistic level of protection as current E-SAPI/E-SBI/X-SAPI/X-SBI at 10% lighter weights (see Figure 4).



The five sizes of plates are extra small (XS), small (S), medium (M), large (L) and extra-large (XL); side plates only come in one size; and lbs means pounds.

Figure 3. SPS VTP Description. Adapted from PM SPIE (personal communication, May 21, 2013).[5]

Two companies, 3M (which owns Ceredyne) and BAE Systems, were awarded engineering and manufacturing development (EMD) contracts for VTP hard armor in September 2013. The EMD contracts had firm fixed price options to develop and deliver VTP plates for ballistic testing. The competing vendors delivered plates for two rounds of first article testing. After successfully passing ballistic testing, the SPS VTP program prepared for a Milestone C, low rate initial production (LRIP) option contract award, planned for June 2015. The program office shared the results of the development program with the Army requirements community (HQDA G-3/5/7 and the Army Training and Doctrine Command). HQDA G-3/5/7, via approved requirements documents, determined the Army acquisition objective for SPS to be 266,000 sets of plates. Procurement of the SPS was planned, programmed, and budgeted with O&M dollars in the Army equipping program evaluation group (EE PEG), overseen by the HQDA G-3/5/7 and ASA(ALT). The SPS procurement funding was placed in the program element managed by the PM, who worked with the Army Contracting Command to award the procurement contract options. Figure 5 presents the EMD results that the competitors achieved with VTP plates. As a result of what was learned to be technically feasible and manufacturable during the EMD phase, HQDA G-3/5/7 modified the requirements in the VTP capability production document (CPD) to achieve the ballistic protection of current hard plates with a weight threshold of 7% less and an objective weight reduction of 30% less than current plates. The AUPC for the VTP (E-SAPI/X-SAPI) was approximately $700, and the AUPC for the VTP (E-SBI/X-SBI) was approximately $450. For this acquisition effort, the big “A” acquisition system worked as intended. The results of the EMD phase from the Defense Acquisition Management framework were used to inform and update the formal production requirements document from the Joint Capabilities Integration and Development System (JCIDS). The Army also prioritized appropriate resources in the planning, programming, budgeting, and execution (PPBE) system for the procurement of the SPS VTP plates.

Vendor	Variant	Weight Reduction	Composition
Vendor A	E-SAPI	**10%**	B_4C + ultra high molecular weight polyethylene (UHMWPE)
Vendor B	E-SBI	**9%**	B_4C/SiC + UHMWPE
	X-SAPI	**8%**	SiC + UHMWPE
	X-SBI	**14%**	SiC + UHMWPE

- Average E variant weight reduction: 9.5% reduction in weight over legacy E-SAPI/E-SBI ***or*** 1.4 lbs reduction per set
- Average X variant weight reduction: 11% reduction in weight over legacy X-SAPI/X-SBI ***or*** 1.98 lbs reduction per set

Figure 4. SPS VTP Development Testing Summary. Adapted from PM SPIE (personal communication, June 3, 2015).[6]

Resourcing and Congressional Involvement

As part of the PPBE system, the Department of Defense (DoD) annually prepares the FY budget, called the budget estimate submission or BES. After adjudication, the BES transitions into the President's budget (PB) request, which is submitted to Congress for review each year in February. The FY16 PB was submitted to Congress in February 2015. Following submission of the PB, congressional hearings are scheduled to help members of Congress and professional staff members understand the PB and subsequently draft important legislation—specifically the annual National Defense Authorization Act (NDAA) and the annual Appropriations Act. The NDAA authorizes programs, policies, and services' end strengths, while the Appropriations Act provides the DoD with permission to obligate dollars (i.e., it basically provides specific DoD funding for programs). The DoD cannot spend government money on programs without those programs first being authorized in an NDAA and subsequently funded in the Appropriations Act.

The House Armed Services Committee (HASC) and the Senate Armed Services Committee (SASC) are responsible for writing the annual NDAA. The House Appropriations Committee (HAC) and Senate Appropriations Committee (SAC) write the annual Appropriation Act. In this case, SASC/HASC/SAC/HAC professional staff members reached out to the appropriate U.S. Army offices to notify them of potential issues with body armor plate industrial base (IB) and associated requested funding levels in the FY16 PB request. Potential issues with NDAA language are coordinated within the U.S. Army through the Office of the Chief of Legislative Liaison (OCLL), whereas potential issues with the appropriation funding levels are coordinated through the Budget Liaison Office in the Army Budget Office within the Office of the Assistant Secretary of the Army for Financial Management and Comptroller (ASA[FM&C]).

An area of emphasis for HASC/SASC/HAC/SAC is the health of the IB in times of limited budgets and declining resources. Of particular interest to the committees is the health of the body armor IB, especially the hard armor plates (which provide ballistic protection) worn by Soldiers and Marines in their ballistic vests. Congress has repeatedly asked for information regarding the health of the body armor IB. The FY13 NDAA HASC report "directed the Secretary of the Army to provide a briefing to the congressional committees that provides an assessment of the long-term sustainment requirements for the body armor industrial base in the United States, to include supply chains for both hard and soft armor" (H.R. Rep. No. 112-479, 2012, p. 59). The next year, section 253 of the FY14 NDAA required "the Secretary of Defense to provide a report on the comprehensive Research and Development strategy of the Army Secretary to achieve significant reductions in the weight of body armor" (NDAA, 2013, p. 127). Finally, the FY15 NDAA Senate report required the Secretary of the Army to conduct a "technical study and business case analysis on the requirements, cost, benefit, feasibility, and advisability of the replacement and refurbishment of the various body armor plates used in personal protective equipment" (S. Rep. No. 113-176, 2014, p. 33).

General Guidance on Industrial Base Planning

DoD acquisition directives and regulations require IB planning for all acquisition programs of record. The documentation and results of IB planning for programs is usually embedded within the acquisition and contracting strategies. The DoD Instruction (DoDI) 5000.02, *Operation of the Adaptive Acquisition Framework*, dated January 23, 2020, states, "PMs will consider acquisition strategies that leverage international acquisition and supportability planning to improve economies of scale, **strengthen the defense industrial base**" (Office of the Under Secretary of Defense for Acquisition & Sustainment [OUSD(A&S)], 2020, p. 10). The accompanying DoDI 5000.02T, *Operation of the Defense Acquisition System*, provides more guidance under IB analysis and considerations for PMs, stating that

> Program management is responsible for incorporating industrial base analysis, to include capacity and capability considerations, into acquisition planning and execution. The industrial base considerations should be documented in the Acquisition Strategy and include identification of industrial capability problems (e.g., access to raw materials, export controls, production capabilities) that have the potential to impact the DoD near- and long-term, and identification of mitigation strategies that are within the scope of program management. (OUSD[A&S], 2020, p. 85)

Chapter 2, "The Industrial Base," in *Defense Manufacturing Management Guide for Program Managers* contains comprehensive guidance for IB planning (DoD, 2012). The PM's IB planning responsibilities originate from the Defense Production Act of 1950, of which two titles are still authorized and relevant:

- Title I - Priorities and Allocations (the authority to demand priority for defense-related products under contract)
- Title III - Expansion of Productive Capacity and Supply (the authority to provide incentives to develop, modernize, and expand defense productive capacity) (DoD, 2012)

The authorities of Defense Production Act of 1950 cannot force commercial companies to enter government contracts with the DoD. These titles allow the DoD to incentivize commercial industry to enter into contracts with the DoD and subsequently enable the DoD to place "ratings" on the contracts. Work on "rated" contracts would be prioritized over "nonrated" contracts. The procurement contracts of legacy hard armor and the SPS VTP development contracts were rated as "DO" contracts, meaning that vendors were required to prioritize these efforts over "nonrated" efforts but not as high as "DX" rated contracts if they had any. The FY11 NDAA changed the DoD organization for defense IB policy by establishing the Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy (MIBP) with the following responsibilities:

- Stimulate and support vigorous competition and innovation in the defense IB, and
- Establish and sustain cost-effective industrial and technological capabilities that assure military readiness and superiority (DoD, 2012).

Subsequent legislation solidified the importance of IB planning in defense acquisition programs. 10 U.S.C. 44 § 2440 required consideration of the national technology and IB in the development and implementation of acquisition plans for each major defense acquisition program. A PM is responsible for knowing the capabilities of their IB and integrating those considerations in their risk assessments, acquisition planning, and program implementation. 10 U.S.C. 148 identified five specific statutory requirements with the DoD for IB planning:

- Section 2501 sets national security objectives for the IB
- Section 2502 establishes the IB council, headed by the Secretary of Defense
- Section 2503 establishes a program for the analysis of technology and the IB
- Section 2504 requires an annual IB report to be submitted to Congress
- Section 2505 requires periodic assessments of the IB

DoDI 5000.60 *Industrial Base Capabilities Assessments* (OUSD[A&S], 2018) and the accompanying DoD 5000.60-H (DoD, 2013) provide policy, identify responsibilities for assessing defense industrial capabilities, and detail the process for conducting assessments of defense IB capabilities. DoDI 5000.60 mandates that government funds will not be used to preserve an IB capability unless national security requirements are at risk and unless it is both cost effective (benefits exceed costs) and time effective (OUSD[A&S], 2018). DoDI 5000.60 also emphasizes the PM's responsibility to perform IB assessments for the milestone decision authority in support of program milestones (OUSD[A&S], 2018). Critical to the success of any program is the ability of the acquisition team to understand the capacity to produce, the capability to produce, and the financial stability required to produce the items required by warfighters. Industrial base planning may include the following industrial preparedness measures:

- Modernizing or expanding facilities
- Developing improved production techniques
- Awarding "pilot line" contracts
- Establishing or maintaining standby production lines
- Maintaining a warm production base
- Acquiring and maintaining plant equipment packages with all the necessary special tools, dies, fixtures, and special test equipment
- Establishing and maintaining multiple production sources
- Conducting special studies
- Pre-stocking raw materials, semi-finished materials, components, and assemblies
- Multiyear contracting
- Establishing programs to increase the retention of personnel with key technical skills
- Exercising authority of the Federal Acquisition Regulation and Defense Production Act
- Recommending design changes or waivers
- Underwriting the establishment/maintenance of U.S. production sources for critical defense material when no current U.S. source exists

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Hard Armor Industrial Base Planning

In response to the requirement from the FY13 and FY14 NDAAs, the Army prepared a report for Congress entitled *Secretary of the Army's Response to Congressional Defense Committees on Body Armor Research & Development and Sustainment Strategies* on March 28, 2014 (personal communication, March 28, 2014).[7] The report provided a status of current PPE systems, an overview of research and development efforts to improve protection and reduce Soldier load (weight), and a PPE IB assessment. The Army's goal was to maintain at least two vendors to maintain competition and promote innovation. With respect to hard armor plates, the Army acknowledged two vendors, BAE Systems and 3M–Ceradyne, as producing current plates through DLA contracts. These same two vendors were awarded SPS VTP development contracts for lighter weight hard armor plates. The HQDA G-4 highlighted that current inventory of hard armor plates were available to meet contingency and training requirements in the near term. In this same report, DLA stated the short-term risk assessment (FY14 and FY15) for hard armor IB as significant due to a considerable drop in demand and vendors operating below their stated minimum sustaining rates (MSRs). DLA assessed the long-term risk (FY16 and beyond) as significant due to a low demand, dependence on the DoD, and an 18-month estimate to reconstitute the capability if vendors stopped production.

The Army Program Management Office updated its hard armor industrial base assessment in June 2014, concluding that the current planned funding levels for sustainment buys of legacy E-SAPI/X-SAPI and E-BSI/X-SBI, combined with planned SPS procurements of VTP E-SAPI/X-SAPI and VTP E-SBI/X-SBI, would fall below the funding levels required for the MSRs of the vendors. Only BAE Systems and 3M–Ceradyne remained qualified vendors for hard armor plates. 3M–Ceradyne stated that their MSR of production was 12,000 plates per month, and BAE's MSR was 10,000 plates per month (PM SPIE, personal communication, June 2014).[8] The Army inspected about 550,000 hard armor plates per year with nondestructive test equipment (NDTE), using X-ray technologies to check for ceramic cracking and delamination issues from 2008 through 2014 (PM SPIE, personal communication, June 2014).[9] Based on the failure rate (or washout rate) of the total inspected plates per year, the service life of E-SAPI and X-SAPI was estimated to be 10 years, and the service life of the E-SBI and X-SBI was estimated between 34 and 69 years (PM SPIE, personal communication, June 2014).[10] The Army also concluded that the washout rate did not depend on the age of the plates (PM SPIE, personal communication, June 2014).[11]

In August 2014, the Institute of Defense Analysis (IDA) published a report for DLA entitled *Department of Defense Hard Body Armor (HBA) Industrial Base and Supply Chain Assessment: Boron Carbide (B_4C) Crude and Refined Powders.* The report found that the current hard armor vendors were reliant on limited and specific commercial sources for B_4C powder but that a healthy global IB existed for B_4C powder should DoD have future supply challenges (Institute of Defense Analysis [IDA], personal communication, July 16, 2014).[12]

The Office of Manufacturing and Industrial Base Policy (MIBP) published a study of the hard armor industry by the RAND Corporation as part of the comprehensive sector-by-sector, tier-by-tier (S2T2) analysis in September 2014 (Office of the Under Secretary of Defense for Manufacturing and Industrial Base Policy, personal communication, September 12, 2014).[13] The S2T2 is a standardized industrial base analysis approach and methodology for assessing the health of the defense IB. Its objectives are to

- Establish early warning indicators and identify IB risk
- Analyze the effect of DoD portfolio decisions on the IB
- Analyze single points of failure, unreliable suppliers, overreliance on foreign sourcing, and areas of limited competition, particularly at the lower tiers of the supply chain
- Define plans and strategies for mitigating identified IB risks
- Support long-term planning and investment decisions by and across the Services

The S2T2 process assessed the fragility (characteristics that make a specific capability likely to be disrupted, answering the following questions, Will the DoD receive what it needs, and when it needs it?) and criticality (characteristics that make a specific capability difficult to replace if disrupted with a capability defined as either a technology, part, component, or product). The hard armor industry segments included hard body armor (systems integration), ceramic tiles, B_4C ceramic powder, UHMWPE fibers and laminates, and aramid fibers and weaving. Recommendations included the following for the entire supply chain from the system integrator to tile manufacturer to ceramic powder supplier and the UHMWPE/aramid fiber producers/weavers:

- Consider funding to MSRs of production.
- Consider stockpiling hard armor plates or B_4C powder.
- Consider IB maintenance contracts (IBMC) to help preserve capability and surge capacity. IBMCs cover fixed costs while production remains lower than full surge capacity.
- Consider increasing the investment in future hard armor plates, ceramic tiles, and/or UHMWPE/aramid fibers for either increasing protection and/or achieving lighter weight.

One important consideration from the S2T2 analysis that complicated IB planning was that the manufacturers had different business operating models. 3M–Ceradyne operated with a vertically integrated business model—meaning the company owned and operated a mine for the raw ceramic powder, a ceramic tile manufacturer, and a hard armor plate integration and assembly plant, all in different locations. BAE Systems, on the other hand, operated with a horizontally integrated business model—meaning the company procured ceramic tiles from the commercial market and then owned and operated the hard armor plate integration and assembly plant at a single location.

In February 2015, the RAND Corporation completed a comprehensive assessment of the PPE on behalf of the Office of the Under Secretary of Defense for Acquisition, Technology & Logistics (OUSD[AT&L]). A subset of the RAND report findings included

- The DoD has large inventories of current designs and little need to buy more in the short term.
- Few alternative markets for military-grade PPE exist, so the industry is shrinking.
- Industry is unlikely to invest in research and development for PPE in the absence of large DoD contracts.
- The most critical technologies are ceramic tiles, high-performance polyethylene, and aramid fibers. (Younossi et al., 2015)

The report recommendations included

- Consider implementing industrial strategies to ensure future access to critical technologies, such as
    - Implement IBMCs for hard body armor and ceramic tiles to cover a share of fixed costs while production remains low.
    - Stockpile or establish a U.S. source for B_4C ceramic powder.
- Employ a best-value approach to source selections with an increased emphasis on criteria tied to weight, ballistic performance, and form/fit improvements rather than a cost-focused strategy, which would help incentivize innovation.
- Continue to use a multipronged strategy to support the research and development ecosystem, given that innovations can arise from various sources. (Younossi et al., 2015)

The RAND report summarized the hard armor supply chain in Figure 6.

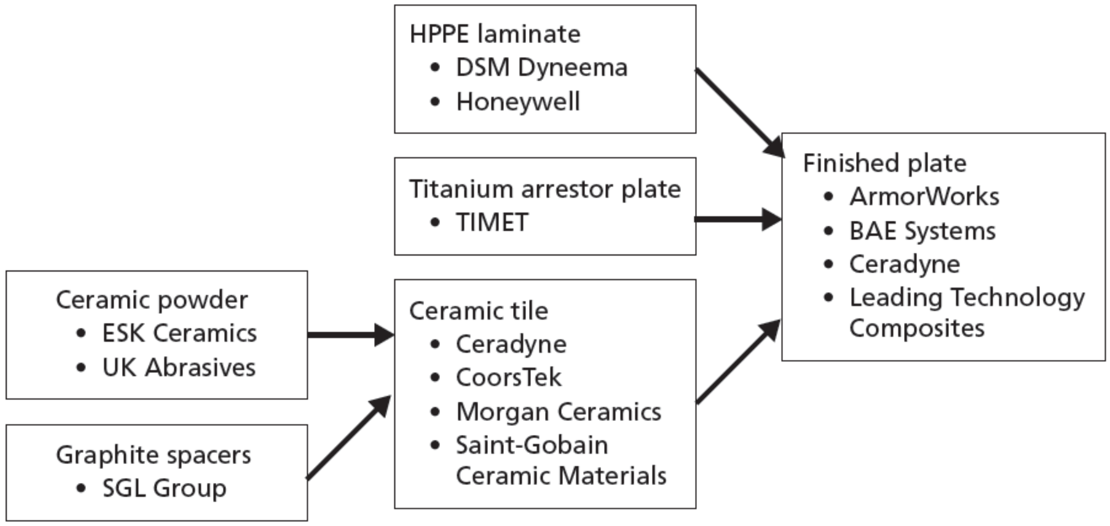

Figure 5. Hard Armor Supply Chain. Source: Younossi et al. (2015).

As directed in Public Law 113-66, the FY14 NDAA, the OUSD(AT&L) provided Congress with the *Department of Defense Report to Congress on Personal Protection Equipment* in February 2015 (OUSD[AT&L], 2015). This report built upon the conclusions on the previously referenced studies. With respect to IB concerns, the report listed the following risk mitigation steps being considered: “the use of Industrial Base Maintenance Contracts, stockpiling, changes in procurement strategies, and qualification of domestic suppliers” (OUSD[AT&L], 2015, p. 14). More generally, “Opportunities to rely on commercial markets, demand for defense unique products, cooperative international developments and foreign sources, and adequate transfer of technology are key factors to sustaining a healthy industrial base capable of responding to future requirements” (OUSD[AT&L], 2015, p. 14). The report continues:

> Funding available for initial procurement of SPS during the FY2016–2020 timeframe will likely be at or potentially even below most producers’ Minimum Sustaining Rates of production. Therefore, as soon as it is practicable after SPS subsystems have entered into FRP, the Army should consider ceasing the sustainment of older versions of body armor and helmets, and apply its sustainment funds toward procuring SPS variants of body armor and helmets. This “Modernization through Sustainment” strategy would help to ensure

> that the Army is modernizing its stockpile of PPE assets, even as it begins initial procurement of the SPS. In addition, and equally as important, using sustainment funds to procure the latest systems will help the Army to maintain and support the most current and capable production base. (OUSD[AT&L], 2015, p. 21)

In response the FY15 NDAA, the Army completed a report to Congress entitled *Technical Study and Business Case Analysis of Body Armor Plates* in February 2015 (Headquarters, Department of the Army [HQDA], 2015). The service life of current hard plates was determined by the Army and presented in Table 1.

Table 1. Hard Armor Service Life and Washout Rates. Adapted from HQDA (2015).

	Expected Service Life	**Annual Washout Rate**
E-SAPI	10.3 years	6.48%
E-SBI	42.2 years	1.63%
X-SAPI	17.6 years	3.86%
X-SBI	85.2 years	0.81%

The Army's PEO Soldier calculated the estimated service life from the annual washout rate of currently fielded hard body armor. The washout rate was based on the total number of plates that failed inspection, divided by the total number of plates inspected during the years 2008 to 2014. The PEO's methodology and results were validated by the Army Materiel Systems Analysis Activity (AMSAA) and were based on hard armor surveillance testing data collected from nondestructive test equipment. The appendix contains the Army's business case analysis presented to Congress in this report.

Case Study Questions to Consider

The PM and deputy PM considered the wealth of information that existed with respect to the hard armor IB planning. As they pulled together the various reports and studies, they formulated a list of questions to address with stakeholders to prepare senior Army leaders for congressional hearings regarding the body armor IB and the concerns raised by commercial industry:

- Who were the stakeholders for hard armor IB?
- What were the DoD/Army and industries' assessments of the hard armor IB, and why did they differ?
- What did the DoD/Army do with the FY15 $80 million funding Congress provided for hard armor plates?
- What was the hard armor IB plan moving forward?
    - Should the Army buy higher performing SPS plates at a higher cost or lower performing legacy plates at a lower cost?
    - What was the inventory requirement for plates from an operational standpoint?
    - Should the Army buy plates to the operational requirement or to maintain the industrial base?
    - Was preserving one or two vendors preferred when maintaining the industrial base?
- What were the advantages and disadvantages of various options to preserve the IB: funding as MSRs, stockpiling, awarding IBMCs, pursuing FMS sales, and/or investing in future innovations?
- What were the recommended hard armor IB actions for Congress to consider with respect to potential NDAA language and potential marks to the PB request in the Appropriations Act?

IB planning challenges are routinely faced by PMs as they formulate acquisition strategies for their assigned programs. The DoD and services face IB challenges across the portfolio of DoD products and services provided to the warfighters. Stakeholders' identification and engagement remain critical to thoroughly study all options and consider second- and third-order effects of various options. A difficult trade-off balance exists between the affordability of investing in a healthy and robust IB for every warfighter capability. At the one end of the affordability spectrum, it’s important to determine the minimum viable level to sustain the production of warfighter capability and support surge capability/capacity for contingency and emergency operations to maintain readiness. At the other end of the affordability spectrum, it’s important to encourage broad participation by commercial industry with companies of all sizes to compete and innovate in order the push the technology envelope to produce better performing warfighter products and services. Limited budgets force the services to accept risk in certain areas because of the ever-increasing demand for greater capabilities and the need to maintain an IB capable of preserving national security interests. The balancing of these IB priorities requires a thoughtful, data-driven approach to optimize limited resources.

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Appendix. Business Case Analysis.

This appendix is adapted from the report to Congress entitled *Technical Study and Business Case Analysis of Body Armor Plates* (HQDA, 2015).

Hard Armor Production Status

At this time, 3M–Ceradyne (Cosa Mesa, California) and BAE Systems (Phoenix, Arizona) are producing E-SAPI plates under DLA TS contracts. Ceradyne is delivering 9,000 plates per month, and their deliveries will be complete by the second quarter of FY16 (2QFY16). BAE is delivering 6,000 plates per month and will complete deliveries by 1QFY16. BAE's contract expires for new delivery orders in July 2015, and Ceradyne's contract has already expired for new delivery orders. Leading Technology Composites Inc. has an indefinite delivery, indefinite quantity (IDIQ) contract in place for E-SBIs that expires on May 30, 2016. There are no contracts for X-SAPI or X-SBI, as they are not being used, and the Army is maintaining a stockpile of 147,000 sets of X-SAPI and 150,000 sets of X-SBI for future contingencies.

Based on the status of the current stockpile, the Army has no plans to procure any additional E-SAPI or E-SBI plates with sustainment funding after current deliveries under DLA TS contracts are completed. The Army does plan to begin LRIP of lighter weight E-SAPI and E-SBI, and X-SAPI and X-SBI plates under the SPS program beginning in 4QFY15. The number of complete sets of SPS hard body armor that will be produced per year in full rate production (FRP) is estimated to be 20,760 per year. FRP begins in FY16. This equates to 41,520 E-SAPI and X-SAPI plates, and 41,520 E-SBI and X-SBI plates.

For the purposes of comparison to stated industry MSR of production, the planned production rates amount to five to ten months of production per year for one producer. Production and inventory levels are presented in Figures 7, 8, and 9. On-hand inventories of hard armor plates by DLA and the Army enabled the calculation of plate inventories level per year.

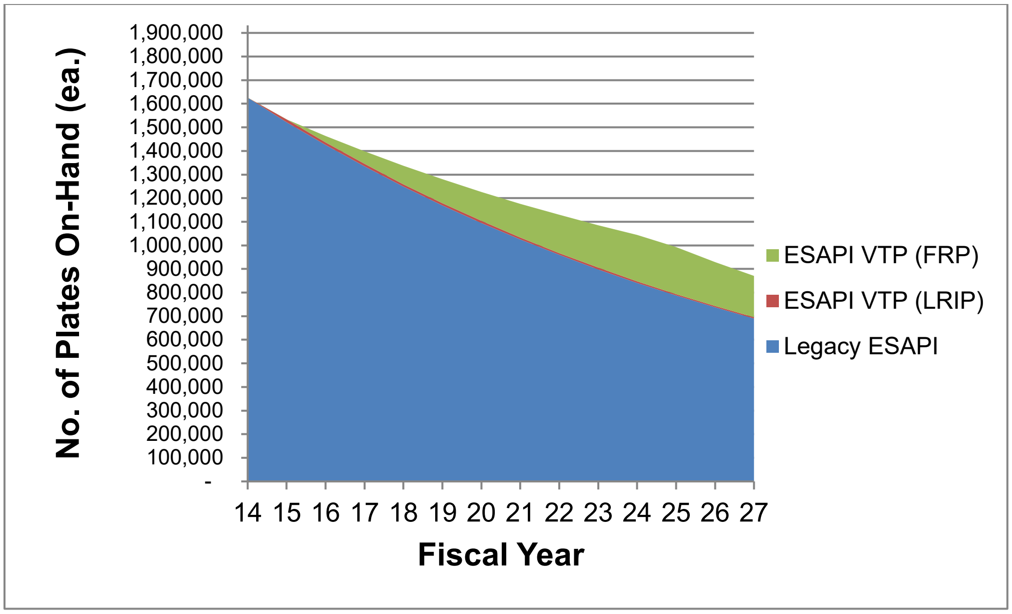

Figure 6. E-SAPI Expected Inventory Levels. Adapted from HQDA (2015).

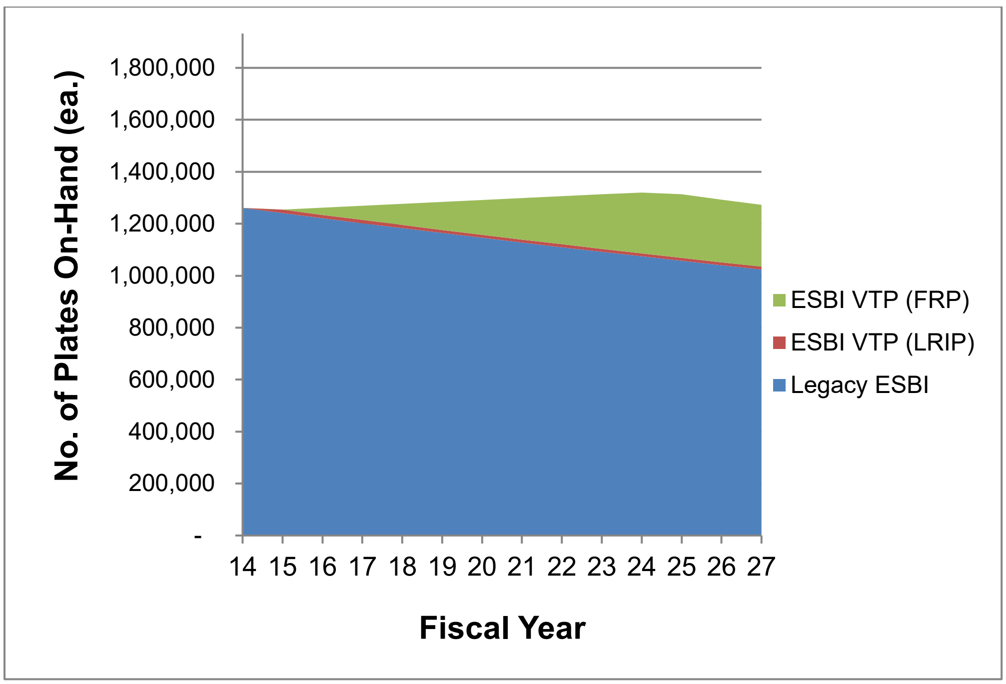

Figure 7. E-SBI Expected Inventory Levels. Adapted from HQDA (2015).

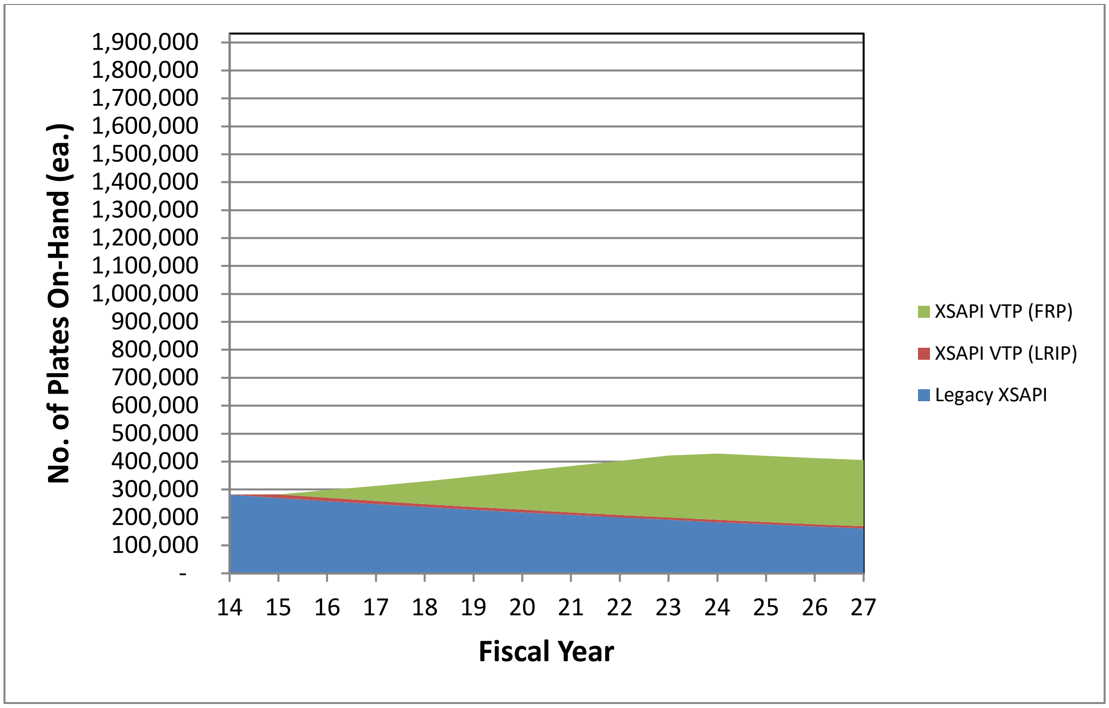

Figure 8. X-SAPI Expected Inventory Levels. Adapted from HQDA (2015).

Hard Armor Industrial Base Study

The SPS provides a modular, scalable integrated system of mission tailorable ballistic protective subsystems at a reduced weight, while maintaining the same level of ballistic protection and mobility provided by the current PPE systems. The SPS system includes VTP hard armor.

The Army will not be manufacturing sufficient quantities of SPS hard armor plates from FY15 to FY20 to support two hard body armor contractors. The stated MSR of the Army's two current producers ranges between 6,000 and 12,000 torso plates (E-SAPI or X-SAPI) per month.

The Office of the Secretary of Defense (OSD) and the DLA have recently completed studies to address the industrial base. The OSD study was conducted by the RAND National Defense Research Institute to address section 146 of the FY14 NDAA. The OSD study generated the following key findings and recommendations relating to hard body armor:

- Recognize that reduced procurement is inevitable in the short term due to the existence of large inventories of hard body armor.

- Continue to foster innovation and competition through the development process.
- Focus research, development, test, and evaluation (RDTE) investments on more innovative efforts with alignment to long term acquisition priorities.
- DoD should sponsor studies of the feasibility of IBMCs aimed at prime contractors and ceramic tile producers to cover a share of fixed costs while production remains low.
- Contract for MSR if possible and affordable.

The DLA study was accomplished by Deloitte and recommends an IBMC be awarded in FY16 for only one supplier and include a ceramic tile manufacturer. This IBMC should be targeted to preserve surge production capability.

Path Forward

In the FY15 NDAA, $80 million in funding authorization was included for the body armor IB. The Army intends to use the $80 million to procure the lighter weight SPS VTP E-SAPI and E-SBI, and X-SAPI and X-SBI plates for production in FY16 in lieu of procuring legacy plates. Table 2 quantifies the discriminating differences between legacy plates and SPS VTP plates. The congressional add will procure a minimum of 35,320 complete sets of lighter body armor (front, back, and side plates), utilizing an SPS VTP existing contract.

Table 2. Hard Armor Plate Comparison. Adapted from HQDA (2015).

	Material	Weight (each)	Cost (each)	Capability
Legacy E-SAPI	Boron Carbide (B_4C)	5.45 lbs	$472	7.62 mm hardened steel penetrators and **some** 5.56 mm tungsten carbide penetrators
Legacy X-SAPI	Silicon Carbide (SiC)	6.00 lbs	$450	7.62 mm tungsten carbide penetrators and 7.62 mm hardened steel penetrators
VTP E-SAPI	Boron Carbide & Silicon Carbide	5.07 lbs	$719	7.62 mm hardened steel penetrators and **some** 5.56 mm tungsten carbide penetrators
VTP X-SAPI	Silicon Carbide	5.58 lbs	$708	7.62 mm tungsten carbide penetrators and 7.62 mm hardened steel penetrators

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