NATIONAL SECURITY ASSESSMENT OF THE HIGH PERFORMANCE EXPLOSIVES AND EXPLOSIVE COMPONENTS INDUSTRIES

A Report for the U.S. Department of the Navy

Prepared by

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Foreword

The Indian Head Division, Naval Surface Warfare Center (NSWC) of the Naval Sea Systems Command requested this national security assessment of the high performance explosives and explosive components sector. NSWC Indian Head was concerned about the ability of its suppliers of high performance explosives and explosive components to produce their products in the future. Additionally, NSWC Indian Head was concerned about the dwindling investment in research and development, which historically has led to the development of explosive materials for new applications. A key question was the degree to which suppliers' capabilities had been weakened by an extended period of declining defense budgets.

High performance explosives are substances that go through a rapid chemical reaction (decomposition) that produces an expansion of hot gas at an extremely high rate. For the purposes of this report, only those material formulations that have a rate of reaction that is faster than the speed of sound are considered high performance explosives (HPEs). Other materials (propellants and pyrotechnics) produce heat and an expansion of gasses -- but they have a rate of reaction below the speed of sound.

A high performance explosive component (HPEC) is a weapon, or subassembly of a weapon, that utilizes an HPE as its source of destructive power. Examples of HPECs are artillery shells, warheads for missiles, bombs, fuzes, detonators, etc. Some of these items (e.g., a fuze) use only small amounts of very sensitive HPEs. Other HPECs such as the main explosive charge of a bomb or artillery shell use larger amounts of less sensitive HPEs.

The U.S. Department of Commerce's Bureau of Export Administration (BXA) is delegated the authority under Section 705 of the Defense Production Act of 1950, as amended, and Executive Order 12656 to collect basic economic and industrial information from industry. These provisions enable BXA to gather data essential to assessing the capabilities of the U.S. industrial base. With these assessments, the government can develop policy alternatives that will improve the capabilities and competitiveness of specific industrial sectors and support the national defense.

The Office of Strategic Industries and Economic Security (SIES) is the operating unit within BXA with the responsibility for this data collection and analysis. The Strategic Analysis Division of SIES performed this assessment with technical support from NSWC Indian Head. SIES has worked with the armed services in conducting over 30 national security assessments in the past 10 years. These studies have focused on a wide range of industries that are of great importance to the armed services. Such assessments include ball and roller bearings, gears, robotics, semi-conductors, ejection seats, and cartridge and propellant actuated devices (CAD/PAD).

Executive Summary

The United States' supplier base for high-performance explosives and related components -- products essential to the defense of the nation -- has been operating under increasing stress since the late-1980s. Reduced production orders and lower revenues have made it difficult for both federal government production facilities and private companies to maintain their full capabilities.

It is critical that the United States be an innovator and leader in the HPE and HPEC industries -- and it maintain a broad capability to manufacture compounds and components. To remain competitive in the field, both technologically and in manufacturing know-how, forward-looking management will be required of U.S. government agencies and of private-sector suppliers.

Manufacturers of high performance explosives (HPEs) and high performance explosive components (HPECs), whether U.S. government-owned production operations or private companies, face a number of challenges in the years ahead. Munitions R&D dollar spending been falling for the past 10 years, and will continue to fall another 50 percent by 2005, according to Defense Department projections. Munitions R&D is also falling as a percentage of the overall Defense R&D budget. In addition, some manufacturers report an aging of their workforces—a phenomenon that is found in these organizations' research laboratories as well as in their production facilities.

For the moment, the nation does not face a supply crisis in HPE and HPECs. But if the United States is to retain sufficient explosive production capacity for the future, greater thought must be given in the next few years on how to maintain infrastructure—in terms of manufacturing facilities, trained personnel, and R&D.

This study examines these matters and other factors affecting the HPE and HPEC industries. The recent history of these industries as well as future needs are covered in the report, which looks at a range of issues, including:

- Shipments in units and dollars
- Employment
- Investment in operations
- Financial performance
- Research and development
- Comparison of U.S. and selected foreign manufacturers of HPEs/HPECs
- Competitive assessment of U.S. respondents

BXA Assessment Findings

The HPE and HPEC industries are small. The 33 organizations responding to BXA's survey had combined HPE and HPEC shipments of approximately $513 million[1] in 1998 and employed approximately 7,900 people in the United States. These organizations were located in 17 states, with the most numerous concentrations in California and Tennessee.

Overall Performance of the HPE and HPEC Industries

While U.S. manufacturers of HPECs were relatively successful from 1995 to 1999, the nation's largest supplier of HPE was in crisis, a situation that affected both the company's federal government and private customers. The U.S. government-owned Holston Army Ammunition Plant[2] (HSAAP), which dominates HPE production in the United States, lost many of its customers. The reason: rising product prices attributed to high overhead expenses and reduced demand for its HPE products.

Department of Defense (DoD) weapon systems program managers reacted to these higher prices by finding cheaper foreign alternatives. As a result, HSAAP's overhead problem grew bigger because rising costs were spread over a smaller customer base, which drove prices even higher.

In 1998, the U.S. Army solicited bids for a new supplier of HPEs. The Army selected Royal Ordnance[3] (a part of Great Britain's BAE Systems) as the new manager for its underutilized HSAAP facility.

Production was stopped except for a few items. The result of this "shutdown" and change of contractor was a 55 percent reduction in HPE shipments. During this time, it appears that the vast majority of the weapon system programs that left HSAAP bought their HPEs from overseas vendors located in Norway and Sweden.

Royal Ordnance, the first foreign contractor to manage HSAAP, immediately began reorganizing the government manufacturing facility's operating structure, lowering costs, and significantly reducing prices for HPEs. Royal Ordnance is currently trying to win lost customers back as contracts expire.

In contrast, private U.S. manufacturers of HPECs experienced an upward trend during the mid-to late-1990s. Shipments from these producers, as measured in dollars[4], rose 12

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[1] Two government-owned, contractor-operated facilities could not provide shipment data in the form requested.
[2] HSAAP is located in Kingsport, TN. HSAAP produces HMX and RDX, HPEs with many defense applications.
[3] Royal Ordnance is a British company, which manufactures explosive materials. BAE Systems, an aerospace conglomerate, owns Royal Ordnance.
[4] Dollars over time are not adjusted in this assessment.

percent from 1995 to 1999.[5] However, all is not well for U.S. HPEC producers. As might be expected, the spending downturn at the Department of Defense over the last 15 years has reduced the HPEC sector's capital investment. It has lagged the rest of U.S. manufacturing for over 10 years, according to Census Bureau data.

Future Budget Trends – Procurement, Research and Development Slide

The Department of Defense munitions budget funds both the HPE and HPEC industries. The budgets for munitions procurement and for R&D have fallen substantially since the mid-1980s. According to DoD, from 1986 to 1998, procurements of munitions (the primary finished product for HPEs and HPECs) dropped 81 percent.[6] This steep budget decline caused firms to leave the HPEC business, resulting in consolidation of the remaining suppliers. Procurement expenditures for munitions by DoD are expected to stabilize at between $4.3 and $4.6 billion a year from 2002 to 2005. This level of spending should help stabilize the remaining firms in both the U.S. HPE and HPEC industries as long as the majority of contracts are awarded within the U.S. industrial base.

R&D expenditures are an investment in the future. However, since its 20-year high in 1989, DoD spending on munitions research, development, testing, and evaluation (RDT&E) has fallen nearly 45 percent. According to current projections, RDT&E spending on munitions will plunge another 50 percent to about $820 million by 2005.

What makes this issue even more serious is that munitions RDT&E is also falling as a percentage of DoD's overall RDT&E budget. Munitions RDT&E was between four and six percent of the overall DoD RDT&E budget from 1986 to 2000. After 2000, however, the munitions portion shrinks to about 2.4 percent of the overall defense RDT&E budget. This reduced investment in RDT&E may slow innovation and hinder the ability of the United States to field cutting-edge munitions technologies.

Reduced RDT&E spending will almost certainly degrade the ability of firms and government organizations to hire and retain scientific and technical staff. Drastic budget cuts will send a loud signal to the chemistry and physics communities that there are few opportunities in the field of high performance explosives. Scientists and engineers will simply vote with their feet—opting to "follow the money" to financially healthier areas of research.

Potentially serious employment issues with scientists, engineers, and production workers await the HPE and HPEC industries in the next decade. As the BXA survey results and anecdotal[7] evidence suggest, a generation of HPE and HPEC workers are expected to

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[5] Increasing shipments in what appears to be a declining market may be due to a small increase in munitions procurement spending from 1995. The effects of spending increases and decreases often lag a year or more, according to the Director of the Munitions Industrial Base Task Force.

[6] Office of Munitions, Office of the Secretary of Defense.

[7] Anecdotal evidence is evidence based solely on in-person and telephonic interviews with industry officials, conducted by BXA.

retire in the next 10 to 15 years. It is uncertain whether this approaching loss of workforce knowledge will be avoided.

If R&D initiatives and workforce skills erode, then there will be a reduced capability of the HPE and HPEC industries to deliver to DoD effective and innovative munitions in the future. DoD and industry officials must start planning now for replacing an aging workforce.

Production Capacity Ownership – Federal and Private

Production of HPEs and HPECs in the United States is divided between facilities owned (and in some cases operated) by the U.S. government and facilities operated by private industry. The government-owned facilities were constructed before and during World War II and have the capacity to make very large amounts of products. These plants have been used during times of prolonged conflict (World War II, the Korean War, and the Vietnam War), but often their capacities have been underutilized or unutilized during times of peace.

Most government-owned, contractor-operated (GOCO) plants currently run at low workloads compared to their total capacities, raising the GOCOs' expenses and increasing the cost of items produced. However, these federal production facilities are the only plants capable of replenishing the stocks of certain types of ammunition and ammunition components used by the armed forces. Department of Defense policy requires the replenishment of ammunition stocks within three years of a major conflict.

GOCOs compete at times against the smaller and sometimes more agile contractor-owned, contractor-operated facilities (COCOs). While providing similar products, frequently at a lower price, COCOs cannot manufacture items in the volume needed in time of war. These companies also lack the capacity to replenish the U.S. stockpiles of particular munitions to mandated levels within the required three years.

With greatly reduced defense spending, there are fewer orders for both GOCOs and COCOs to win. GOCOs, with their larger overhead, often find it difficult to compete against the prices offered by the smaller COCOs. COCOs often view military orders awarded to GOCOs not as contracts that are awarded because of best price but as an effort to keep GOCOs in business.

U.S. HPE Production Capability – Rebounds with HSAAP'S Overhaul

No other producer, in the United States and possibly the world, can manufacture the variety and the quantity of explosives that HSAAP can produce. Since taking over operation of the complex from the Holston Defense Corporation, the previous GOCO operator, Royal Ordnance has brought down the price of HPEs substantially. The new operator delivers bulk HPEs to the Army at a fixed price, and offers competitive contracts for HPEs to other DoD weapons systems programs.

To achieve this turnaround, Royal Ordnance has reduced overhead expenses, reconfigured the production plant, changed HSAAP's organizational structure, and leased out space on the facility site to commercial tenants. As a result, the economic viability of HSAAP is improving.

As with HSAAP, commercial U.S. manufacturers of HPEs have been hurt by cutbacks in government orders. These private companies are very small compared to HSAAP and they focus on manufacturing HPEs for specific applications: unique military products, oil exploration, and focused research and development programs. Shipments from these producers fell almost 21 percent from 1995 to 1999, with one producer accounting for most of the drop.

Shipment Trends – Mixed Performance, Uncertain Future

Shipments of high performance explosives decreased nearly 55 percent from $78.9 million to $35.6 million from 1995 to 1999, according to the BXA survey. The primary cause of the decrease was the cutback in production and subsequent temporary closure of HSAAP. The outlook for future HPE shipments is uncertain. Royal Ordnance is challenged with winning back lost customers who turned to foreign suppliers, principally in Norway and Sweden.

Unlike HPE production in the United States, which decreased substantially between 1995 and 1999, shipments of HPECs stayed level or increased slightly with sales climbing nearly 12 percent to $441 million as compared to $394 million in 1995.

Employment Concerns – Looming Problems for Industry

Skilled employee issues are among the most difficult challenges facing this sector. Work with HPEs is inherently dangerous, especially on the production side, where large amounts of energetic materials can be involved. The safety concerns alone call for an experienced, well-trained work force. In addition, the unique manufacturing talents of the process operator historically have influenced the quality of HPEs and HPECs.

The result of the early 1990s "peace-dividend" for many in the U.S. HPEC industry has been the lowest level of employment seen since 1963.[8] When these munition industries downsize, they frequently retain older workers, running the risk of losing talent when a generation retires. Anecdotal evidence collected through interviews with corporate executives and government officials who work in the munitions sector suggest that some "brain drain" of scientists, engineers, and production workers has already occurred in both the HPE and HPEC communities.

[8] Historical employment data from the Bureau of the Census is used in this report from 1963 to 1998. The definition for Standard Industrial Classification (SIC) Code 3483 (Ammunition over 30mm) has remained consistent since 1963. However, the definition changed significantly in 1963; therefore, data before 1963 is not comparable.

Survey respondents report that some of the most troublesome bottlenecks, which prevent manufacturers from achieving full production, are labor related. If all of the labor issues (labor availability, labor training, and expertise) reported by the respondents are combined, they may constitute the industries' most significant challenge -- and could require the greatest amount of time and money to solve.

Investment in Operations – Capital Spending Lags Manufacturing

Investment information collected by the Bureau of the Census and BXA shows a lack of new investment in the HPEC community. Census data indicate that private sector producers of HPECs are not investing in their operations on par with the rest of U.S. manufacturing.

Before recovery in 1997, HPEC industry capital expenditures[9] had fallen 84 percent from its peak in 1988. While the rest of U.S. manufacturing has achieved capital expenditure growth from approximately $5,500 to $7,500 per employee for the period of 1988 to 1996, the HPEC industry's capital expenditure growth was comparatively miniscule, fluctuating at approximately $1,000 to $2,000 per employee.

Research and Development – Long-Term Decline Affects Industry

All of the armed services have steadily cut spending on R&D for munitions (which includes HPEs and HPECs) in recent years. DoD funding for research, development, testing, and evaluation (RDT&E) for munitions is expected to continue on a downward slope. By 2005, DoD RDT&E spending is projected to be 70 percent below 1989's peak funding level of $2.8 billion.

The funding reductions break the historical support patterns for munitions R&D at DoD. Munitions RDT&E is falling as a percentage of DoD's overall RDT&E budget. Munitions RDT&E averaged four to six percent of the overall DoD RDT&E budget from 1986 to 2000. By 2005, however, the munitions portion is expected to sink to about 2.4 percent of the overall Defense RDT&E budget.

R&D spending by BXA-surveyed private companies and GOCOs engaged in manufacturing HPEs and HPECs fell 12.3 percent from 1995 to 1999. Outlays for HPE and HPEC R&D by federal agencies plummeted nearly twice as much – by 23 percent. The decline in R&D has damaging effects. It not only slows the development of new materials and munitions, but it also limits the ability of firms to hire and retain scientific staff to work on R&D projects.

While overall support for R&D is falling, some private HPE and HPEC companies continue to try to leverage their limited R&D budgets. Six firms within the HPE and HPEC industries have established relationships with seven universities to undertake joint

[9] For definition, please see the Census Bureau's *Ammunition (Except Small Arms)*, 1997 Economic Census Manufacturing Report (http://www.census.gov/prod/ec97/97m3329g.pdf), page A-5.

R&D projects. The majority of these projects were sponsored exclusively with company funds. Most of the firms that have collaborated with universities plan to collaborate again if a worthwhile project materializes. At least one firm has funded research at multiple universities.

Import and Export Issues – Foreign Regulatory Hurdles Thwart U.S. Firms

HPE and HPEC producers have experienced various difficulties exporting their products. The causes for exporting delays come from both the purchasing nations and the U.S. government. Some countries require approved export licenses for proposed sales and mandate that shipments must be delivered by the purchaser's ships rather than by carriers chosen by the U.S. producer. As a result, shipping delays can occur, which can produce cost increases and reduce cash flow for U.S. manufacturers. Other survey respondents reported that their firms have been forced to comply with defense trade offset agreements required by foreign governments, a market-distorting trade barrier that can significantly erode profits of U.S. producers and undermine their economic viability.

Munitions trade with Canada is another area of concern for the U.S. industrial base. Canada has special access to the United States' defense market through bilateral agreements. In many cases, Canadian companies are treated like U.S. firms. Canada is even considered a part of the U.S. technological and industrial base by DoD. American HPEC companies, however, do not have the same access because of restrictive procurements by the Canadian government. In addition, U.S. companies are often penalized by having to enter into offset agreements on their sales to Canada.

HPE and HPEC producers face delays in receiving export licenses, which can prompt customers to consider foreign sources of supply. Survey respondents urged that the United States government expedite export licenses, and they requested that the Departments of State and Commerce practice more uniformity in their licensing procedures.

The Competition – U.S. Industry Compared to Selected Foreign Suppliers

Many nations are capable of producing HPEs and HPECs. European manufacturers (Sweden and Norway being the most prolific suppliers) of HPEs are the strongest competitors to the United States' primary source of HPEs -- HSAAP. Several European producers surveyed by BXA have not reduced production of HPEs as much as HSAAP – and in one case, have increased production. These firms have been able to sell more of their products in the U.S. due to the rise in HSAAP's HPE prices starting in the mid-1990s and its temporary closure in 1998. HSAAP's shipments declined approximately 55 percent from 1995 to 1999 because of these two factors.

Most European manufacturers have small home markets for their products and are looking to exports as a major source of revenue. One of their main target markets is the United States. Future market penetration by foreign manufacturers of HPEs is expected to be deterred by the competitive prices now offered by HSAAP.

U.S. Government Procurement – Fragmented Operations, Policies

Factors besides competition affect the HPE and HPEC sectors. One of the most important is the federal government. The U.S. government is the customer, partner, competitor, and regulator in these industries. Firms have to comply with follow regulations developed by the Departments of Defense, State, Commerce, and Transportation; the Environmental Protection Agency; and others.

Environmental Regulations – Loose Rules Overseas May Skew Competition

The production and use of HPEs and HPECs creates hazardous wastes. In many cases, the HPEs themselves are hazardous materials, capable of contaminating the environment. Environmental regulations over the past 30 years have become stricter for U.S. companies and this trend will most likely continue. Compliance adds to the cost of production, making it more difficult for firms to compete internationally in the HPE and HPEC markets with nations that may not have the same level of regulation.

Operating costs for some U.S. HPE and HPEC operations may escalate in the future as companies have to bear the cost of cleaning up contamination at their sites. The energetic materials sector, including HPE and HPEC manufacturers and particularly the government-owned and/or operated facilities, does not have a strong record of environmental stewardship. This potential for incurring higher cost is affirmed in the Energetic Materials Environmental Study published by DoD's Strategic Environmental Research and Development Office. The study found that government facilities were slower to address environmental issues than the private sector.

A key policy question that DoD top management and munitions procurement officials must consider is whether it is appropriate for the department to buy HPEs from foreign suppliers that may have environmentally "dirtier" manufacturing operations and as a result of those operations gain a cost advantage over U.S. firms.

Future of the Industries – Prospects Mirror Curve of Declining Demand

Respondents were neutral to optimistic about their own future, but pessimistic about the future of their industries. Many HPE and HPEC producers stated that their individual prospects in the next five years would remain the same or improve somewhat. When the respondents spoke of the future of their industries as a whole, however, they used descriptions such as "bleak" or "very poor" because of the declining demand for their products and reduced R&D spending.

Several survey respondents predict that more consolidation will occur within the HPEC industry in the future. To some extent, this activity is healthy to the extent that it brings stability to DoD's supplier base. Three recent mergers, in fact, are viewed by some industry executives as having increased the capability of the suppliers to provide more complete product solutions to the U.S. military.

Recommendations

Issue 1. – Research and Development

Research and development spending has been falling in the HPE and HPEC industries, according to DoD and BXA data. Since 1989, RDT&E spending has fallen 45 percent. According to current projections, DoD support for munitions R&D will plunge another 50 percent to about $820 million by 2005. This decline represents a historical shift in support for munitions R&D. The munitions RDT&E budget is falling from approximately four to six percent of the total DoD RDT&E budget (1986-2000) to about 2.4 percent by 2005.

Anecdotal and survey evidence collected by BXA suggests that the HPE and HPEC industries could suffer a major loss of engineering and scientific talent in the next 10 to 15 years due to declining defense funding and a graying workforce. BXA recommends that DoD take the following steps to reverse this trend:

Recommendation A

DoD should restore munitions funding to its 14-year average of between four to six percent of overall RDT&E spending. This level of spending would come much closer to providing the resources required for maintaining a culture of innovation within federal and private research facilities. Higher funding levels are essential if DoD is to retain existing professional staff and is to develop new technical talent.

Recommendation B

DoD should establish a $10 million-a-year, competitive research grant program that would be open to U.S. industry and U.S. government research organizations. Both organizations can enlist U.S. research universities in their research program, when it is deemed necessary. This program should be designed to bolster basic and early-applied research capabilities with the goal of developing new and improved energetic materials to meet national security needs.

The scope of the R&D program should be determined by a multi-service panel, which includes at least two representatives of the U.S. HPE industry and two members affiliated with top research universities. Research grants can be for one, two, or three years, depending on need. An expert peer-review panel should award these grants on a competitive basis. This funding should be used to supplement (not replace) funds normally spent by industry and government on munitions related R&D. The R&D grant program should target specific engineering and scientific challenges identified by the multi-service panel at the outset of the program.

Recommendation C

There should be an expansion of R&D efforts funded under DoD's ManTech Program to support the munitions community's pursuit of process improvements that promise product performance gains, safe process and materials handling, methods for reducing manufacturing costs, and ways to lessen manufacturing-related environmental impacts.

Issue 2. – Purchasing of HPEs from Non-U.S. Sources

In the 1990s, DoD procurement officials increasingly purchased their HPEs from cheaper foreign sources instead of U.S. suppliers, principally HSAAP. The procurement decisions reduced production volumes at HSAAP -- and drove HSAAP's overhead costs and product prices for HPEs even higher. Consequently, even more defense procurements were shifted away from HSAAP.

While DoD procurement officers are supposed to consider "best value" factors in making their purchasing decisions, their deliberations appear weighted in favor of product pricing. Potentially less restrictive environmental rules in some countries may give foreign suppliers a pricing edge in procurements. U.S. suppliers may also be disadvantaged by temporary swings in financial markets, which elevates the dollar relative to other currencies to unusually high levels.

Recommendation A

Procurement officers within DoD should comply with requirements that they consider economic, trade, industrial base, and environmental factors affecting U.S. suppliers of HPEs in making price-based decisions in awarding supply contracts to foreign vendors.

Recommendation B

DoD should not allow supplier acceptance of trade offset obligations to be a deciding factor in the scoring and selection of HPE suppliers.

Recommendation C

DoD should investigate whether a "Buy America" provision is needed for HPEs to ensure a responsive U.S. manufacturing base. The department should consider establishing a minimum tonnage threshold for annual purchases for U.S. HPE suppliers. A technical advisory panel should determine the level of domestic production that is adequate to maintain the economic and technical health of the U.S. HPE manufacturing sector—and to guarantee that national security requirements can be met.

The "Buy America" provision would only activate when annual purchases dropped below this threshold and would be deactivated when DoD purchases exceeded the threshold by 5 percent. DoD would be free to buy HPEs from foreign suppliers except when domestic manufacturers' volumes drop below the threshold level. In no instance

should DoD be prevented from buying from foreign suppliers those explosive materials and compounds that are not available from domestic manufacturers.

Issue 3. – Recycling of HPEs (Opportunity and Challenges)

One third of the respondents to the BXA survey expressed interest in the concept of recycling HPEs. The recycling of HPEs is consistent with the intentions of the September 1998 Executive Order 13101, which mandates greater use of recycled material in all government operations, including munitions.

Currently, several firms are developing processes to remove HPEs from warheads and rocket motors. Many technical issues, however, need to be resolved before recycled HPEs can be used in military applications. In addition, recycled HPEs could adversely affect the economics of producing virgin HPE material at HSAAP by reducing production volume to less than acceptable levels.

Recommendation

The Department of Defense should form an industry/government panel consisting of engineering and manufacturing experts to investigate the utility of recycled HPEs in defense applications. This panel should examine and report on the technical challenges, economic opportunities and impacts, environmental liabilities, and related safety issues associated with recycling HPEs. This panel should deliver a final report to DoD within 18 months.

Issue – Role of U.S. Government-Owned Manufacturing Capacity

The U.S. Army owns significant manufacturing capacity within the HPE and HPEC sectors. A U.S. law, called The Arsenal Act[10], requires that the Army manufacture its supplies (including HPEs and HPECs) in government-owned factories -- presuming the plants can manufacture the item on an economical basis. In 1998, the U.S. Army published what appears to be a contradictory instruction, the Industrial Base Policy Letter 98-1. It states that the Army should rely on the private sector for its ammunition needs and transfer government manufacturing assets to the private sector "to the maximum extent feasible." The goals of the Army's 1998 policy letter do not appear to be fully compatible with federal law.

Recommendation

The U.S. Army should either amend or eliminate its Industrial Base Policy Letter 98-1 to produce consistency with the Arsenal Act; or it should seek legislative action by the U.S. Congress to amend or eliminate the Arsenal Act.

[10] Title 10 U.S. Code 4532

Introduction

This assessment addresses the health and competitiveness of the high performance explosive (HPE) and high performance explosive component (HPEC) sectors. The products manufactured by these sectors typically are components for finished munitions, or are manufactured as finished munitions.

Importance to National Defense and Visibility Issues

HPEs and HPECs are critical to the national security of the United States. All advanced weapons platforms are ineffective if they do not have quality munitions.

The United States must maintain an adequate capability to develop and manufacture HPEs and HPECs. Any time the U.S. enters into a conflict, recent examples being Desert Storm and Kosovo, HPEs and HPECs demonstrate their importance on the battlefield. The entire chain of HPE research, development, and production needs to be kept viable and intact if these industries are to produce new materials and final products. Skills and knowledge within this sector would be extremely difficult, time consuming, and expensive to replace.

HPEs and HPECs, unfortunately, are not nearly as visible as the combat systems that use them. This is especially true for non-precision or "dumb" munitions. When military systems are used, most people see aircraft, ships, or tanks -- not the munitions expended by these platforms. Although critical to defense missions, HPECs and HPEs in particular do not enjoy the same level of advocacy that the weapons platforms receive in the budgetary process.

It appears, in the future, that HPEs and HPECs will account for less of the percentage of value of munitions. The trend toward precision or near precision weapons indicates that munitions will have increasingly sophisticated guidance systems. These guidance systems will most likely be the most costly parts of the munition and will therefore receive the most funding.

The U.S. HPE Industry in Particular Faces Challenges

Many countries possess a capability to manufacture HPEs and HPECs. Most if not all nations want to possess the capability to make munitions for their forces in order to maintain a level of self-sufficiency. No nation wants to rely on another nation for its ammunition needs. The manufacture of munitions and HPEs does not require the same national commitment of resources as required for building ships or aircraft. Consequently, countries are less prone to accept imports of HPEs and HPECs and tend to protect their own suppliers.

Because of its high fixed overhead costs, Holston Army Ammunition Plant (HSAAP), the primary U.S. facility for the manufacture of military HPEs, has been at times non-competitive against lower priced imports. Reacting to higher prices, some managers of U.S. military weapons programs have bought HPEs overseas to reduce program costs.

The recent production reorganization of HSAAP has achieved lower production costs and improved HPE pricing. Nevertheless, exchange rates and offset agreements will continue to favor imports. One of the top markets for foreign manufacturers will continue to be the United States.

Background

The U.S. Department of the Navy, Indian Head Division of the Naval Surface Warfare Center (NSWC Indian Head) requested this national security assessment of HPE and HPEC sectors. NSWC Indian Head was concerned about the future production capabilities of its HPE and HPEC suppliers. A key issue is the degree to which suppliers' capabilities have been weakened by an extended period of declining defense budgets.

The U.S. Department of Commerce's Bureau of Export Administration (BXA) is delegated the authority under Section 705 of the Defense Production Act of 1950, as amended, and Executive Order 12656 to collect basic economic and industrial information from industry. These provisions enable BXA to gather data essential to assessing the capabilities of the U.S. industrial base. With these assessments, the government can then develop policy alternatives that will improve the capabilities and competitiveness of specific industrial sectors and support the national defense.

The Office of Strategic Industries and Economic Security (SIES) is the operating unit within BXA with the responsibility for this data collection and analysis. The Strategic Analysis Division of SIES performed this assessment with technical support from NSWC Indian Head.

SIES has worked with the armed services in conducting over 30 national security assessments in the past 10 years. These studies have focused on a wide range of industries that are of great importance to the armed services. Examples of these assessments include: ball and roller bearings, gears, robotics, semi-conductors, ejection seats, and cartridge and propellant actuated devices (CAD/PADs). The Explosives and Undersea Weapons Unit of NSWC Indian Head recommended that a report on the high explosives industry be undertaken.

Methodology

SIES prepared a comprehensive mandatory survey for firms in the HPE and HPEC industries to complete. The U.S. Army, Navy, and the Department of Energy assisted in the development of the survey document.

The Survey Document

The survey asked organizations to provide information on specific production capabilities, recent production line shutdowns, shipments; barriers to exports, imports of key manufacturing equipment and raw materials, shortages of any kind, employment and financial information, research & development (R&D) expenditures, environmental and safety regulations, and assessments of competitive prospects.

Mailing of Surveys

The mailing list used for this study was assembled from several sources. The Navy and the Army provided lists of critical suppliers to be surveyed. At BXA's request, the Bureau of Alcohol, Tobacco, and Firearms, which licenses manufacturers, distributors, and merchants of explosives, provided a roster of known manufacturers.

BXA mailed the survey to 250 public and private organizations. Although this number was far larger than the actual number of high performance explosive and explosive component producers, BXA and the Navy wanted to ensure that the mailing would cover organizations doing work in this area. Firms that were not producers of HPEs or HPECs sent in exemption forms. The majority of these exempted organizations produced energetic materials for applications such as automotive airbags, blasting agents for mining, special effects for movies, fireworks, and construction blasting.

Respondent Description

Twenty-eight distinct U.S. respondents provided information to BXA regarding 33 different organizations. In some cases, a respondent spoke for more than one organization. The respondents included managers of federal government-owned ammunition plants and privately owned facilities *(See page 8 for a discussion on the two types of organizations).*

The capabilities of the organizations varied. HPE manufacturers produce explosive compounds from chemical raw materials. An example of this kind of operation would be HSAAP. Its products are rarely finished goods, but rather materials for the munitions manufacturing chain.

Another type of surveyed organization, HPEC manufacturers use explosive compositions to form warheads and other items such as projectiles (large and medium caliber), detonators, fuzes, and other devices. These manufacturers were greater in number and accounted for the majority of the HPE/HPEC industries' sales. Many of the HPEC respondents also integrated finished munitions (called load assemble and pack (LAP)

operations) in their facilities. LAP organizations use a variety of methods to form explosive charges out of HPEs *(See **Table 1** on page 7)*.

Site Visits and Other Forms of Research

During the course of the study, BXA staff visited nine government- and industry-owned facilities. Three of the facilities were located in Europe. The site visits provided an opportunity for firms to discuss issues critical to their industry that were not covered in detail by the survey. Each operation has its own heritage, culture, and business constraints, which affected their management and their business decisions.

BXA used Census Bureau data to supplement BXA survey data. BXA's survey data covered the period from 1995-1999. Census data was used to give a historical perspective on the HPEC industry, as well as to compare it to all U.S. manufacturing. BXA also attended several munitions conferences and symposiums during the study to meet with members of the munitions community and to hear about industry-wide successes and challenges.

The Military High Performance Explosive and High Performance Explosive Component Industries

What is an Explosive?

According to the Merriam-Webster®dictionary, explode can mean, "to undergo a rapid chemical or nuclear reaction with the production of noise, heat, and violent expansion of gases." An explosive detonates or burns through the substrate at a rate *above* the speed of sound. Depending on several factors, the leading edge of the detonation travels between one and nine kilometers per second through the explosive material.

Differences Between Explosives and Propellants

A propellant burns when ignited with the leading edge of the burn front moving *slower* than the speed of sound through the material. Propellants are used to perform physical work to move an object, e.g., propelling a projectile out of the barrel of a weapon. In many cases, an explosive would be impractical as a propellant, because of the short duration of its burn and the associated extreme pressure an explosive would cause in a confined space. High performance explosives are used, however, as ingredients in some propellants such as solid rocket fuel.

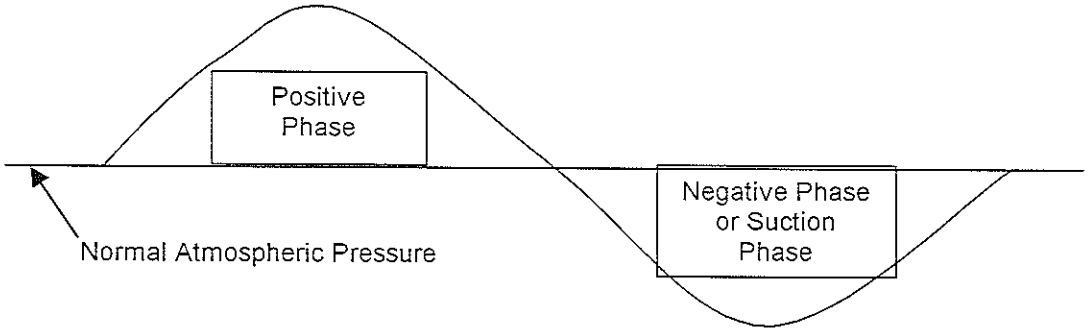
Differences Between Explosives and Pyrotechnics

Pyrotechnics burn at a much slower rate than explosives. Pyrotechnics are useful for their ability to generate heat, light, and smoke. Systems such as illumination flares, decoys for infrared guided missiles, and smoke generators use pyrotechnics. Explosives, propellants, and pyrotechnics all fall under the broad title of energetic materials. For the purposes of this report, however, propellants and pyrotechnics are not included in this report.

Why are High Performance Explosives Useful?

An explosion creates a shock wave (or compression wave) that raises the local atmospheric pressure within a nanosecond to a very high level. Within a longer period, measured in hundredths of a second, the pressure returns to normal and then goes below normal atmospheric pressure. This event is the negative or suction phase. *(See **Figure 1** below)*. The positive and negative phases produce a push-pull effect that, when combined with the large amount of heat created by the explosive, will damage or destroy the target.

Figure 1
The Phases of an Explosion



High performance explosives use this extreme force in several applications to defeat the target. For example, a shaped charge consists of an explosive that has an open area on the inside shaped like a cone. Upon detonation, the cone concentrates its energy into a point, increasing its power at that point. Some shaped charges contain metallic liners that are placed in the cone, which forms molten jets of metal that force their way through armor plating or other obstructions.

Another application for HPEs is in general purpose high explosive artillery rounds, which use small fragments from the metal case surrounding the explosive to damage or destroy a target. These weapons are used against personnel and non-armored targets in the open.

Mixed Properties of Explosives

Explosives have a variety of properties, some of which are not desirable. To attain maximum performance, HPEs are frequently mixed. Since some HPEs are very sensitive to initiation from shock, heat, static electricity, or decomposition, inert ingredients are added to alter the properties of HPEs to make them less sensitive and give them the desired physical properties.

Often the main challenge in creating high performance explosives is creating an explosive compound that has several opposing characteristics. If one were to create the perfect HPE, it would have the following characteristics:

1. Low cost production
2. Long shelf life
3. Little or no toxicity
4. Resistance to water
5. Low sensitivity to inadvertent initiation
6. Low volatility
7. High density
8. Extremely high energy release

This set of qualities, however, is difficult if not impossible to produce. Consequently, compromises are made in almost all formulations.

Not only do chemical compositions of explosives vary, but their physical forms can have many configurations. The application of the explosive is the driving factor in the physical form of the charge or warhead. **Table 1** below illustrates some of the various processes used to make finished explosives.

Table 1: Physical Forms of Finished Explosives Common Military Applications	
Process	**Important Traits**
Pressings	Explosives and additives are pressed into a die.
Melt Castings	A heated, liquefied explosive is poured into a mold or into the finished munition. A frequently used example is TNT.
Plastic (or Polymer) Bonded Explosive (PBX)	RDX or HMX[11] combined with plastic or polymer binders. The PBX is poured into a finished munition and cures solid.
Putties	Mixture of powdered explosives and plasticizers. They can be molded to a desired shape.
Rubberized	Explosives are combined with plasticizers or polymers and rolled into large sheets.
Extrudables	Explosives are combined with uncured silicone rubber resin to make a material that is extruded without heat and can fill the needed space. The resin is cured with heat to make the material hold its shape.

Source: Cooper, P., Kurowski, S., *Introduction to the Technology of Explosives*

What is a High Performance Explosive Component (HPEC)?

For the purposes of this assessment, an HPEC is a weapon or subassembly of a weapon that utilizes an HPE as its source of destructive power. Examples of HPECs are artillery shells, warheads for missiles, bombs, fuzes, detonators, etc. Some of these items (e.g., a fuze) use only small amounts of very sensitive HPEs. Other HPECs such as bombs or artillery shells use larger amounts of less sensitive HPEs.

In the case of an artillery shell, the HPEC is close to being a finished product. In other cases; however, as for a warhead for a guided missile, the HPEC (the warhead) is one of several subassemblies (rocket motor, electronics, fins) that make up the finished missile. In the missile example, the HPEC might not account for a significant portion of the total dollar value of the weapon.

[11] Both HMX and RDX are high explosives used in numerous warhead applications.

HPE and HPEC Industry Descriptions

The HPE and HPEC industries are small. In 1998, the 33 organizations responding to BXA's survey had combined HPE and HPEC shipments of approximately $513 million and employed approximately 7,900 people. These organizations were located in 17 states with the highest concentrations in California and Tennessee.

Many countries have some form of a munitions industry. Ammunition is a commodity that nations want to have an indigenous capability to produce. The differences around the world in HPEs and HPECs are in the quality and the technology of the final products. Many nations can manufacture unguided munitions, but the more advanced nations are the producers of precision munitions. U.S. companies sell munitions overseas by virtue of the technology and quality of their products.

Production of explosives and explosive components in the United States is divided between facilities owned (and in some cases operated) by the U.S. government and those operated by the private sector. The government-owned facilities were constructed before and during World War II and have the capacity to make large amounts of products. These plants have been used during times of prolonged conflict (World War II, Korean War, and Vietnam War), but often this capacity has been underutilized or dormant during times of peace.

These facilities generally occupy larger tracts of land than those that are privately owned, since they frequently use and store greater quantities of explosive materials. These wartime resources are practically immobile, since the tracts of land on which they are located were purchased over 50 years ago and have developed histories of being granted the necessary environmental permits for the performance of HPE operations. Establishing such high-volume, wartime-essential plants on new grounds would be administratively and politically daunting.

Government-owned plants include both government-owned contractor-operated (GOCO) and government-owned government-operated (GOGO) plants. The eight government-owned plants that currently produce munitions or munition components are:[12]

- Crane Army Ammunition Activity
- McAlester Army Ammunition Plant
- Holston Army Ammunition Plant
- Iowa Army Ammunition Plant
- Lake City Army Ammunition Plant
- Lone Star Army Ammunition Plant
- Milan Army Ammunition Plant
- Radford Army Ammunition Plant

Only two GOGOs exist. One is the McAlester Army Ammunition Plant, which LAPs bombs for the armed services; the other is the Crane Army Ammunition Activity, which produces and refurbishes ammunition for the Army and the Navy. These two facilities

[12] There are also government owned plants that are not active, but are kept in case of replenishment. There are also plants that are considered excess and will be transferred to new owners at some point in the future.

were ***not*** surveyed during this assessment. The U.S. Army's Operations Support Command[13] oversees the operation of GOGO and GOCO facilities.

GOCOs currently operate at greatly reduced workloads compared to their total capacities. Nevertheless, they are, in some cases, the only plants capable of replenishing the supply of certain types of ammunition to the armed forces within three years of a major conflict, a requirement by the Department of Defense. Operations at reduced workloads have traditionally raised GOCOs' expenses and increased the cost of items produced at these plants.

Commercial and government-owned manufacturing facilities, regardless of their production volumes, occupy large tracts of land compared with other types of manufacturing. Working with explosives requires manufacturers to sufficiently separate buildings to prevent a detonation in one building from causing detonations in other buildings. Manufacturers must comply with quantity-distance (QD) regulations that govern how much explosive material can be stored in a building and how close it can be to other buildings.

GOCO facilities were built for high-volume production. They were constructed during World War II when high volumes of ammunition were required to satisfy the war effort. The manufacturing processes for GOCO plants are frequently automated to produce in volume. However, the plants often lack the flexibility to change their production lines quickly because production operations are focused on achieving high volume production of a limited set of products.

The contractor-owned contractor-operated (COCO) plants are often smaller and more agile producers than the GOCOs. As with the government plants, COCO facilities have seen orders for their products drop since the end of the Cold War. Generally speaking, COCOs can respond to market changes faster than GOCOs. BXA staff visited HPEC facilities that can be refitted quickly to meet the needs of the market. Some COCOs have installed equipment on rollers to rapidly reconfigure their production lines.

Despite such advantages in responding to changing markets, COCOs cannot manufacture items in the volume needed in wartime. In many instances, they cannot produce enough quantity to restore the U.S. stockpile of a particular munition to mandated levels after a conflict. Usually, the GOCOs and GOGOs are the only facilities that can fulfill this requirement.

GOCOs and COCOs often compete for the same orders. With the reduction in defense spending, there are fewer orders for these manufacturers to win. GOCOs, with the large overhead of their facilities, often are not price competitive compared to the smaller COCOs. On the other hand, COCOs often feel that military orders awarded to GOCOs are meant to keep GOCOs in business and are not awarded on the basis of best price per item. Private companies state that they are apprehensive about competing against government-owned facilities.

[13] On October 12, 2000, the Industrial Operations Command (IOC) changed its name to the Operations Support Command (OSC)

Industry Classification and Selected U.S. Census Data

The HPE and HPEC industries fall within two subsections of the Census Bureau's Standard Industry Classification (SIC) system. SIC code 2892 identifies explosives. SIC code 3483 identifies ammunition 30 millimeters or greater in diameter, excluding small arms and including items such as artillery shells, torpedoes, and missile warheads *(See Appendices B and C for full descriptions of both codes)*. This assessment utilizes Census data from SIC 3483 to augment survey data in the areas of employment and capital expenditures.

BXA decided not to use SIC 2892 data because it includes products that are not high-performance explosives used by the U.S. military (e.g., dynamite). Likewise, propellants such as black powder and nitrocellulose-based gunpowder are classified under SIC 2892. Census data for SIC 2892 would include a considerable amount of non-military items outside the scope of the BXA survey. Furthermore, this data would be inappropriate for statistical comparison with survey results for the exclusively high performance explosives industry.

BXA utilized SIC 3483 for this assessment because data from this selection method represents the HPEC industry and indirectly the HPE industry, consistent with the participant pool surveyed. SIC 3483 contains the product lines of manufacturers that load, assemble, and pack munitions.[14] The SIC 3483 data accurately represents the HPEC industry and indicates trends and changes in the HPE industry.

The Holston Army Ammunition Plant (HSAAP)

The largest HPE manufacturing facility in the United States is HSAAP. Located in Kingsport, Tennessee, HSAAP is the primary source of military explosives in the United States. Constructed in 1942, it, like many ammunition plants, was built in response to World War II. According to the U.S. Army's Operations Support Command, HSAAP was built at the request of the British government. At its peak in World War II, HSAAP produced over 350 million pounds of explosives per year.

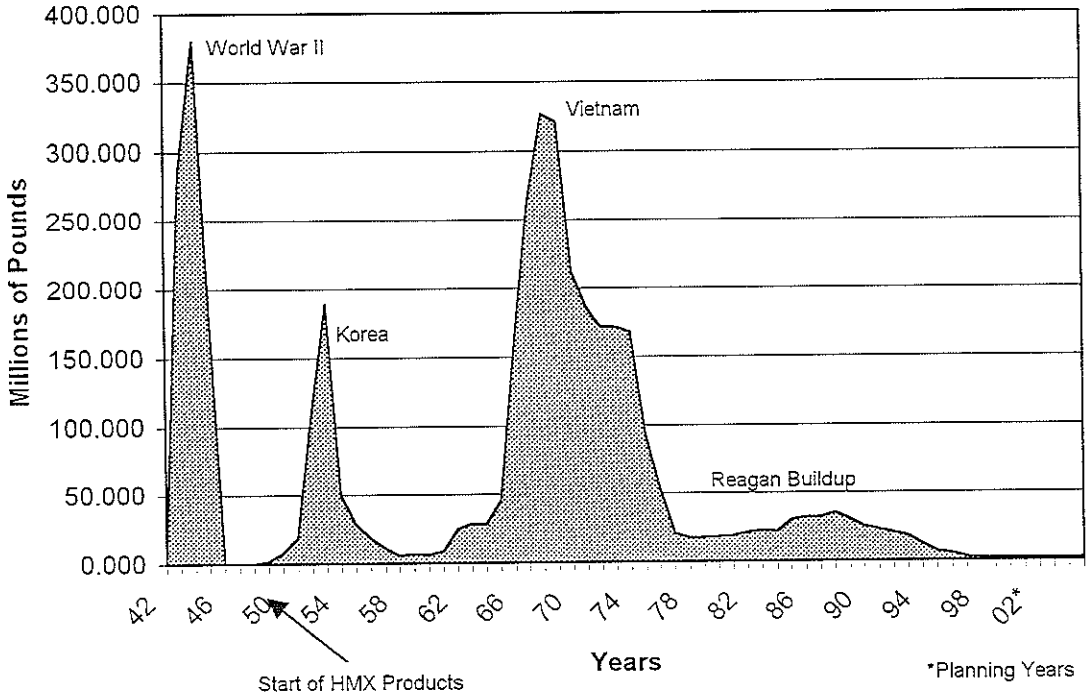
HSAAP can manufacture over seventy variations of the two most prolific base explosives in the U.S. inventory, HMX and RDX. These two HPEs are combined with other explosives or inert ingredients to make a wide variety of finished HPE compounds.

HSAAP's design allows for continuous processing of explosives in large quantities utilizing ten production lines. Continuous processing is not well suited to manufacturing small batch runs. Since the end of the Cold War, HPE requirements have dropped to only several million pounds per year. Manufacturing HPEs in small quantities when combined with high fixed operating costs caused higher per pound HPE prices. In response to price increases, program managers and weapons systems purchasers began to look overseas for alternative HPE sources. This migration of U.S. customers depressed

[14] SIC 3483 does contain products that fall outside the charter of this study; however, such items (mortar fin assemblies, loading of propellant bags, etc.) are demand driven by the armed forces and can serve as a rough gauge for munitions.

manufacturing volume and increased per unit price. Because of these factors, HSAAP had great difficulty in the mid-1990s competing against competitor pricing.

Chart 1: Production Levels at the Holston Army Ammunition Plant



Source: Royal Ordnance North America

In 1998, at the end of HSAAP's operating contract with the Holston Defense Corporation, the U.S. Army held a competition between multiple contractors to find a contractor to supply HPEs. Instead of competing a standard facility use contract, the Army decided to "compete the problem." The Army asked industry to put forward clean paper proposals on how to fulfill the armed services' HPE needs. Royal Ordnance of the United Kingdom won the competition. It will maintain the HSAAP for 25 years under its agreement with the Army.

Royal Ordnance has taken several steps to decrease its HPE prices by addressing HSAAP's manufacturing costs. It has converted one of the continuous manufacturing lines to a batch process to be more price competitive on smaller orders. Royal Ordnance is also attempting to leverage the chemical production facilities at HSAAP to manufacture chemicals for commercial use.

According to Royal Ordnance, it has outsourced functions (e.g., security and fire protection) to a greater extent than the Holston Defense Corporation. Like other GOCOs, Royal Ordnance is actively courting outside companies to use HSAAP's excess facilities and thereby collect lease payments.

Royal Ordnance has availed itself of the Armament Retooling Manufacturing Support (ARMS) program.[15] The ARMS program gives incentives to private companies to move onto ammunition production facilities, such as HSAAP. The facility contractor acts as an industrial park manager. The goals of the program are to

- Create jobs
- Improve the economic stability in regions where munitions facilities are located
- Encourage non-defense commercial firms to use DoD government-owned, contractor-operated facilities
- Increase opportunities for small businesses (small business incubators)
- Encourage small businesses to undertake manufacturing and other industrial processing activities

Through modernization, outsourcing, and greater facility utilization, HSAAP operating costs have decreased enough to yield internationally competitive HPE prices. A fixed price contract with the U.S. Army's Operational Support Command for HPEs has been made as well.

[15] For more information on the ARMS program please see http://www.openterprise.com/

Shipments for the HPE and HPEC Industries

Data collected by BXA indicates that shipment totals in the HPE and HPEC sectors have taken divergent paths. Shipments for HPEs dropped both in dollar value and unit volume each year from 1995 to 1999, chiefly because of reduced DoD orders and the temporary closing of HSAAP. Shipments of HPECs, in contrast, grew during the same period.

Several statistical anomalies affect this shipment data. First, two GOCO facilities did not provide shipment information. These respondents explained that they could not provide shipment data that was compatible to the format used in the BXA survey. Completed items were not always immediately shipped after production, but in some cases were stored on site until requested by the armed services. Consequently, shipments often did not accurately reflect the near-term activity level of the plant. Second, two GOGO ammunition plants were not surveyed in this assessment; therefore, their shipment data is not included.

Census Data on HPEC Shipments

In June of 2000, the Bureau of the Census published comparative statistics from the 1992 and 1997 Economic Census. These comparisons ranked industries by their percent change in shipments from highest to lowest. From 1992 to 1997, HPEC (SIC 3483 - ammunition, except small arms) shipments fell from approximately $3.1 billion to $1.5 billion, a drop of over 50 percent. Of the over 400 SIC numbers that could be ranked, SIC 3483 was ranked second to last. [16]

This data covers the years from 1992 to 1995, before the start of BXA data collection (1995-1999). Much of the post-Cold War decrease in employment occurred from 1992 to 1995, which was not reflected in the BXA data collection.

BXA Survey Data - Shipments in Dollars

According to BXA data, HPE shipments dropped 54.5 percent from 1995 to 1999 *(See **Table 2** below)*. The main reason for this decrease in shipments at HSAAP was decreasing demand and increasing product prices in the mid-1990s, which made its products unattractive to U.S. weapon system program managers. Furthermore, HSAAP changed operating contractors in 1998, which temporarily closed the facility so that it could be reconfigured and re-qualified as a supplier of HPEs to the armed services.

In sharp contrast to the declining HPE shipments, HPEC shipments did not consistently decline over the 1995-1999 period. Sales climbed from $394 million in 1995 to $441 million in 1999 for an average annual growth rate of about 2.4 percent.

[16] Reasons for not ranking specific categories included not having comparable data to work with and not being able to disclose data to protect the identity of respondents.

Table 2: Total Shipments of HPEs and HPECs (Thousands of Dollars)					
	1995	1996	1997	1998	1999
HPEs	78,919.7	72,661.2	74,045.0	57,120.0	35,559.0
HPECs	394,358.8	391,600.0	390,179.6	456,329.4	441,229.9
Bombs, Warheads, submunitions, and Projectiles	**158,461.4**	**170,883.0**	**146,676.9**	**208,069.6**	**189,962.7**
Initiation Devices and Misc.	**235,897.4**	**220,717.0**	**243,502.7**	**248,259.8**	**251,267.2**
Total for HPE and HPEC Industries	473,278.5	464,261.2	464,224.6	513,449.4	476,788.9

Source: U.S. Department of Commerce, BXA Industry Survey

A fair amount of market turbulence between 1995 and 1999 is masked by overall trends for this period. HPEC manufacturers saw shipments drop mildly for two consecutive years in 1996 and 1997, enjoyed a brief spike in demand in 1998, and then watched sales decline in 1999.

Why was the HPEC industry spared from the overall drop in demand experienced by HPE manufacturers? The fact that shipment volumes for HPECs did not follow HPEs downward suggests that the preferred HPE sources changed because U.S. HPEC producers elected to import cheaper, foreign HPEs rather than buy the more expensive domestic HPEs.

BXA and Census Data – HPEC Shipments

At first glance, the BXA survey statistics for HPEC shipments (SIC 3483) appear to contradict Census Bureau statistics. Census statistics indicate declining volumes as opposed to increasing volumes. On closer examination, the alleged contradiction can be resolved.

The BXA survey domain is unique. BXA selected companies from the gross domain considered by the Census Bureau, yielding a subset of companies and assuring lower, reported shipment volumes. Furthermore, BXA in particular did not survey participants on all SIC 3483 items. BXA disregarded items such as metal parts or stabilizing fins. BXA also surveyed on a different year range of 1995 to 1999, as opposed to the Census Bureau range of 1992 to 1997. Consequently, BXA's findings across both gross survey periods and within specific, reported years must be understood as based on different statistical source qualifiers.

Shipments in Units

HPE shipments in units also moved downward from 1995 through 1999. However, the drop in shipments was more pronounced for HPE shipments in units than for HPE shipments in dollars. Shipments in units dropped approximately 70 percent for the five-year period. This phenomenon is due to rising prices per pound for HPEs produced at HSAAP, which made the drop in shipment value less severe. As might be expected, in the case of finished HPECs such as bombs, warheads, projectiles, initiation devices, and other products, unit shipments moved upward overall for the five-year period.

Table 3: Total Shipments in Thousands of Units

	1995	1996	1997	1998	1999
Total Shipments of HPEs (Pounds)	10,417.6	8,476.2	6,360.1	4,666.5	3,105.8
Bombs, Warheads, submunitions, and Projectiles (each)	6,810.6	9,148.1	4,810.9	5,912.8	7,115.0
Detonating Cord and Other Extruded End-Products (Units in Feet)	Not released due to the low number of producers and the high market share of one producer				
Initiation Devices and Miscellaneous (each)	93,953.8	90,119.3	107,750.5	104,524.6	108,082.1

Source: U.S. Department of Commerce, BXA Industry Survey

Employment - Keeping Critical Skills

A disturbance in the supply of HPEs or the ability to integrate them in finished systems would significantly curtail the production of munitions. One of the least visible factors that could create such a disturbance is a loss of critical skills.

HPE and HPEC workers are unique. They have special, hard-to-master skills based on job experience with energetic materials, and they cannot be replaced quickly. These industries require workers who can either manufacture or shape energetic materials. These industries rely on adequate lead and transition times to train replacements. If the core of experienced personnel in these industries were lost without such opportunities to maintain the workforce, the United States' ability to produce HPEs and munitions could be compromised.

For most of recorded history, the manufacturing of explosives was referred to as a "Black Art." People had little or no knowledge of the chemistry and physics of explosives, but rather they followed experience-proven methods with histories of delivering consistent performance. Manufacturing an explosive was a craft, and the most essential information was in the mind of the experienced worker.

Though these industries, in the last decade, have become far more sophisticated in their manufacturing operations, uncertainties still exist. Increased instrumentation on production processes has improved efficiency and quality, allowing manufacturers to better understand the process, increase safety, and improve their products. Still, ongoing research is needed to better understand chemical interactions in the formulation and manufacture of explosives. To overcome the remaining uncertainties, individual experience and skill are required.

There is no room for error in the manufacturing process for HPEs and HPECs, since it is imperative that the finished munition performs reliably. "Dud" rounds can give away the presence of U.S. forces without inflicting damage to the enemy, and rounds that are too sensitive can cause premature detonations.

Census Employment Data for the HPEC Industry

BXA used U.S. Census Bureau data to supplement its employment survey data on the HPEC industry. Tracking SIC 3483 for the HPEC market shows the demand for finished munitions, which in turn is the prime driver of the HPE market.

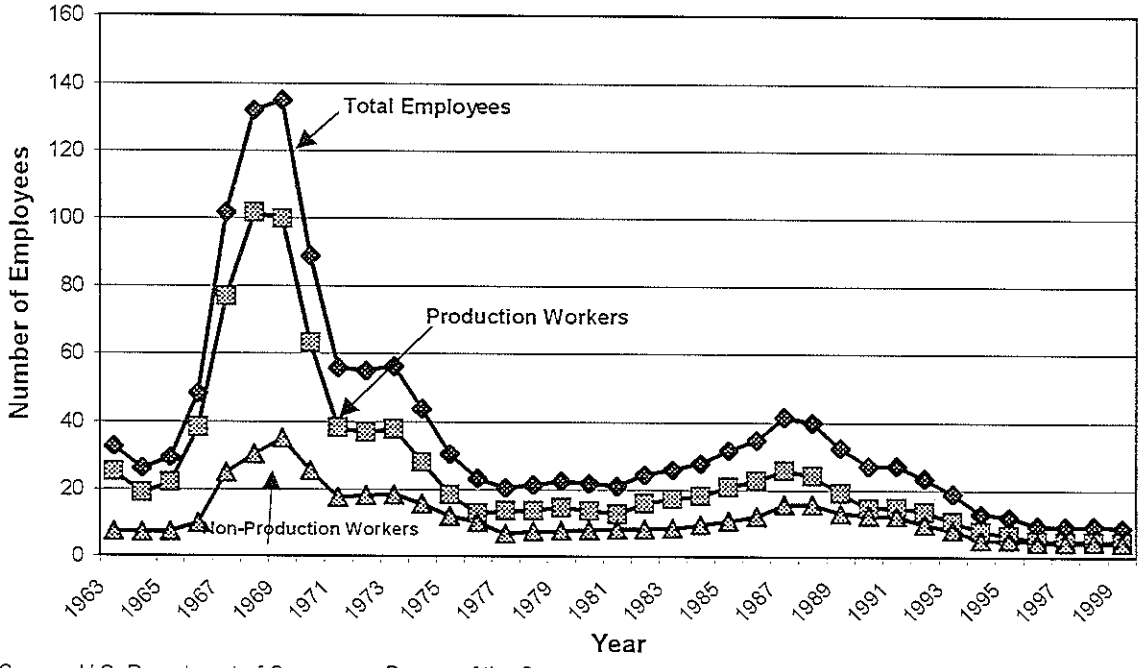
The Census data[17] used by BXA covered the period from 1963 to 1999. In 1999, the number of employed individuals identified against SIC 3483 hit a 36-year low at 8,838 with the production worker percentage of total employment approaching 50 percent *(See*

[17] SIC 3483 was called SIC 1929 before 1972. The historical data begins in 1963 due to a 1963 definition change, which added artillery ammunition and ammunition loading and assembling to the SIC Code. The new NAICS format supplied data for the year 1997. The NAICS number for ammunition except for small arms is 332993. The description for the category did not change for this code, so the NAICS data was combined with the older SIC data.

Chart 2 below). The highest levels of employment occurred between 1965 and 1971, during the Vietnam War, when munitions production expanded greatly. Total employment peaked in 1969 with nearly 135,000 workers producing munitions.

In the last 30 years, employment levels across the industry have taken drastic swings. The Vietnam era, with its high water mark of 135,000 employees, created the greatest ratio of production workers (exceeding 70 percent for several years) to non-production workers. In the late-1970s, total employment fell to approximately 20,000 employees, down 88% - - and remained there until 1982 when the Reagan Administration's military buildup drove up orders and employment. By 1987, employment had risen to 41,000. In 1988, however, a new decline began, though the Gulf War briefly slowed this trend.

Chart 2: Employment Trends for SIC Code 3483



Source: U.S. Department of Commerce, Bureau of the Census

BXA Survey Employment Data

The employment section of the survey document posed a series of quantitative and qualitative questions. The respondents filled out two tables that broke down their workforce by occupation title[18] *(See page 14 of Appendix B for examples of these tables).* Respondents also provided information on employment issues that affect them now and will likely affect them in the future.

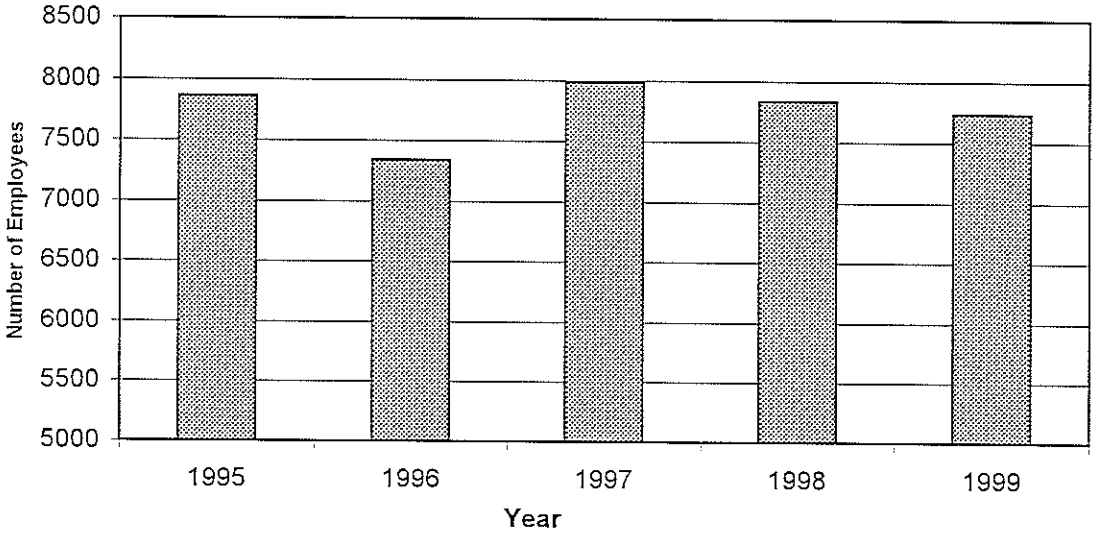
[18] A handful of organizations did not fill out the employment table completely. Two larger respondents were able to provide data on the number of total employees, but could not break down employment data by title for those years. For total employment, data for those two firms are included. Several smaller firms that could not provide data for all years were excluded from the employment data in this report.

The total employment numbers collected by the survey peak in 1997 with 7,961 employees *(See Chart 3 below)*. Production workers primarily led the rise in employment from the five-year low point of approximately 7,400 in 1996. The BXA survey identified at least 272 new production worker slots[19] in this period. Other areas of employment growth were technical services, and, in several cases, administrative workers.

The Director of the Munitions Industrial Base Task Force, Richard Palaschak, explained that the dip and subsequent rise in employment in 1996 and 1997 could be a reflection of the munitions budget. He stated that the effects of the munitions budget often lag from one to two years. A low point for the munitions budget occurred in 1994, so a dip in employment in 1996 was plausible under this scenario.

The ratio of production workers in the surveyed organizations to the total number of their employees is near 50 percent, which is similar to the U.S. Census Bureau data. The small difference in the percentage of production workers between the two data groups is due to the difference in the universe between SIC 3483 and the BXA survey respondents. **Table 4** below shows that the percentage of production workers in the surveyed organizations grew slightly over the survey period.

Chart 3: BXA Data on Employment for HPE and HPEC Industries - Total Employees



Source: U.S. Department of Commerce, BXA Industry Survey

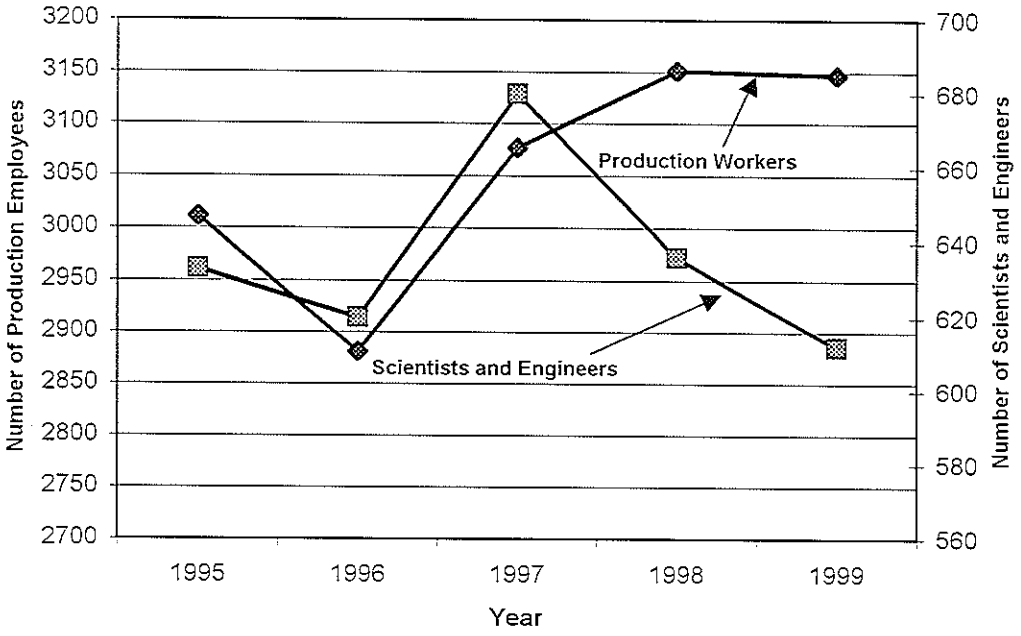
[19] The exact number cannot be calculated because two firms with over 500 employees did not break down their employment numbers. Both firms experienced a rise in total employment, which suggests that their employment of production employees increased as well.

Table 4: Percent of Production Workers to Total Employment					
	1995	1996	1997	1998	1999
Percent of Production Workers vs. Total Employment	48.5	48.6	48.6	49.6	50.6

Source: U.S. Department of Commerce, BXA Industry Survey

From 1995 to 1999, production worker employment in the surveyed organizations was up from a low of about 2,900 to a high of approximately 3,150 *(See **Chart 4** below for an illustration)*. In contrast, the number of employed scientists and engineers in the surveyed organizations followed a different path, finishing 1999 at its lowest point in five years. While the duration of the trend is not sufficient for a definitive conclusion, the ability of firms to conduct R&D appears to be decreasing. In-depth discussion of R&D issues begins on *page 31*.

Chart 4: Production Employees vs. Scientists and Engineers



Source: U.S. Department of Commerce, BXA Industry Survey

The BXA survey asked organizations to distinguish their work forces by various ranges of years of employment. Respondents utilized BXA-provided categories for nine duty descriptions.

In general, survey data suggest that the U.S. HPE and HPEC industries have young-to-moderate age workforces. However, anecdotal evidence collected through interviews indicates that within some employment categories, the industries' ranks are not so youthful. Of particular concern is maintaining scientific/engineering and specialist production skills. The most experienced members of a particular staff can hold much

more institutional knowledge many of the remaining staff. The departure of one or several of these employees can have a large impact on operations.

Employment Concerns

The decline in the size of the U.S. defense sector since the late-1980s has led to a decline in the number of new workers in the HPE and HPEC workforces. When a company in these industries has to reduce its workforce, often the first to go are the less experienced employees. More experienced workers are retained, which in the short term is rarely a problem. In the long term, however, there is a need to pass on critical scientific and production knowledge to a younger generation of managers, researchers, and production workers.

The impact of an aging workforce may be more significant in the scientific and engineering sectors. According to the NSWC Indian Head staff, to fully train a college graduate with a science and engineering degree to work with energetic materials can take five years or longer. Such lead-time, coupled with the anticipated retirements in the next 10 to 15 years, portends the development of a knowledge gap.

The organizations that responded to the survey voiced concerns about finding skilled workers in the future. Company managers noted that they have had difficulties in hiring skilled production workers and engineering staff *(See **Table 5** below)*.

Table 5: Current Labor Concerns

Type of Labor Concern	Number of Mentions
Finding Skilled Workers (Engineering and Production)	6
Union Difficulties	3
Downsizing	3
Tight Labor Market	2
Aging Workforce and Retirements	2

Source: U.S. Department of Commerce, BXA Industry Survey

One manufacturer mentioned during a site visit that it is difficult to attract young professionals to their firm because of its rural location. Since many facilities in these industries are located in rural areas, the problem of attracting young professionals may affect others in these industries. Companies have to compete for employees against high tech firms in urban locations that offer competitive salaries and stock options. The decline of the defense industry appears to have exacerbated this situation. Respondents say that when there is a perception that the defense business is stagnant, it is difficult to convince potential employees to join and stay with the defense industry.

The majority of respondents expect to hire and train new workers to replace departing employees. One organization is using search firms to find critically skilled employees and is offering hiring bonuses and stock options to entice potential employees. Another company is working with state agencies and the local chamber of commerce to improve the skills of local high school students and recent graduates, creating a pool of potential employees.

The supply of skilled labor is critical to the ability of firms to sustain production capabilities into the future and to increase manufacturing output for wartime or replenishment. Respondents identified overall labor supply, labor training, and availability of explosives-related expertise (chemists, process engineers, etc.) as principal bottlenecks that could hinder any effort to rapidly expand U.S. production. The problems were not seen as insurmountable, but resolving them will take time and some investment. Respondents estimated that the cost to address these issues for their companies is approximately $4.3 million *(See **Table 6** below).*

In a national emergency, cost would be less of an obstacle than would the lead-time needed to fulfill these labor needs. The availability of expertise, a finite resource, is the labor bottleneck requiring the longest total and average times for resolution. If the munitions industry were to mobilize, demand for the same kinds of trained professionals from a finite labor pool would create an even more acute shortage of expertise.

Table 6: Labor Bottlenecks

Labor Bottleneck	Cost to Correct (Total)	Cost to Correct (Average)*	Weeks to Correct (Total)	Weeks to Correct (Average)*
Labor Availability	$735,000	$105,000	115	12.7
Labor Training	$2,490,000	$498,000	126	18
Availability of Expertise	$1,075,000	$179,200	168	21
All Three Combined	$4,300,000	$238,900	409	17.0

Source: U.S. Department of Commerce, BXA Industry Survey

* Some firms did not give a cost to correct or weeks needed to correct. Averages are based on the number of firms that provided estimates for this questions.

To respond to the challenge of maintaining employee skills, responding organizations have increased their spending on training. The survey respondents report spending approximately $2,500 per employee on training. Almost 74 percent of the responding firms have increased dollars spent on training in the past five years. One firm's training spending has gone down while four firms, or 17.4 percent, held spending flat *(See **Table** 7 below)*. The expenditures ranged from less than two dollars to $25,000.

Table 7: Dollars Spent on Training per Employee		
	# of Firms that Answered the Question	Dollars Spent (mean)
All Respondents	23	$2,530
Top Two Firms Removed*	21	$1,104

Source: U.S. Department of Commerce, BXA Industry Survey

*Two firms were removed in the second row because they spent significantly more per employee, which more than doubled the mean amount spent on training.

Other Influences on Employment

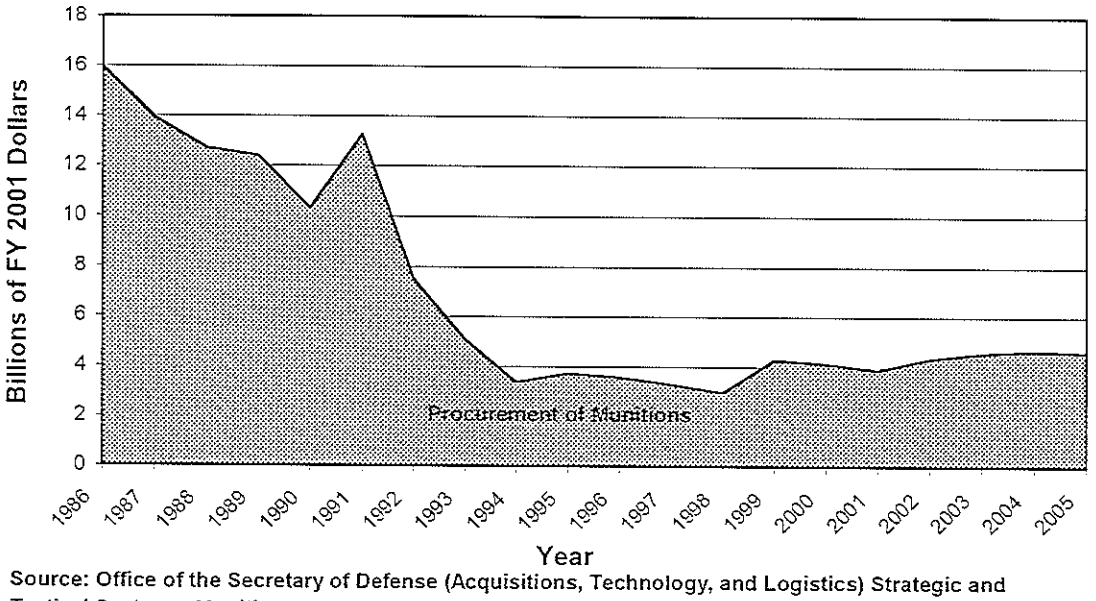
The military budget has been the major factor in the rise and fall of employment in the HPE and HPEC industries. According to the DoD publication *National Defense Budget Estimates for FY 2001,* the U.S. Government's overall spending on national defense decreased $108.6 billion (in constant 1996 dollars) or 29.4 percent from 1987 to 1998.

An important point to consider is that procurement of new systems has fallen at a sharper rate than the overall decline in national defense spending. According to the 2000 *Annual Report to the President and the Congress,* procurement dropped from $138 billion to $45 billion from 1985 to 1996 (in constant FY2001 dollars), a drop of 67 percent.[20]

The procurement budget for munitions has seen an even more dramatic drop in funding *(See **Chart 5** below).*[21] From its high point in 1986 to its low point in 1998, procurement for munitions fell 81 percent in constant FY2001 dollars.

[20] Budget tables were not included in the 2001 Annual Report to the President and Congress.
[21] Dollars for missile defense programs have been removed from Chart 5.

Chart 5: Procurement of Munitions



Source: Office of the Secretary of Defense (Acquisitions, Technology, and Logistics) Strategic and Tactical Systems, Munitions

Some relief in the procurement area may be on the way. The defense budget is forecasted to grow in the next several years, with procurement accounts receiving some of that growth. Procurement expenditures for munitions by DoD are expected to stabilize at between $4.3 and $4.6 billion a year from 2002 to 2005. This level of spending should help stabilize the remaining firms in both the U.S. HPE and HPEC industries as long as the majority of contracts are awarded within the U.S. industrial base.

Another factor that may have contributed to the downturn in employment is productivity rate (output per man-hour). Since 1977 and especially since the early 1990s, there have been large productivity increases, allowing manufacturers to do more with fewer employees. The National Association of Manufacturers reports that productivity for all manufacturing grew at an average annual rate of 3.7 percent per year from 1991-1998.[22]

One respondent stated it was implementing "lean management" to increase its competitiveness. Such action is typical of business trends in computer-aided drawing/manufacturing (CAD/CAM), just-in-time (JIT) inventory, lean manufacturing, and other current manufacturing techniques, which allow manufacturers to produce higher quality products with fewer employees. It appears that the HPE and HPEC industries are beginning to embrace these initiatives.

[22] Please see The Revolution in Growth and Productivity: American Manufacturing in the 1990s, National Association of Manufacturers, July 1999. Last visited 6/19/01. http://205.229.234.180/manu90s.html

Investment in Operations

One important measure of an industry's health is the level of new investment in operations. Growing industries invest heavily in new equipment and technologies that allow them to produce lower-cost products of higher utility and quality. Information collected by BXA and the Census Bureau suggests that investment in the HPE, and in particular the HPEC industries, is not keeping up with U.S. manufacturing in general.

In historical terms, since the late-1980s, investment in operations in the HPEC industry has been shrinking, while investment for the rest of U.S. manufacturing has been growing. The decline in investment is not surprising considering the overall drop in the defense budget. Firms will not invest in markets where there is little or no chance for a return on their capital. However, if little investment is made, then the ability of firms within this sector to innovate and produce in the future, or even maintain current capabilities, could be compromised.

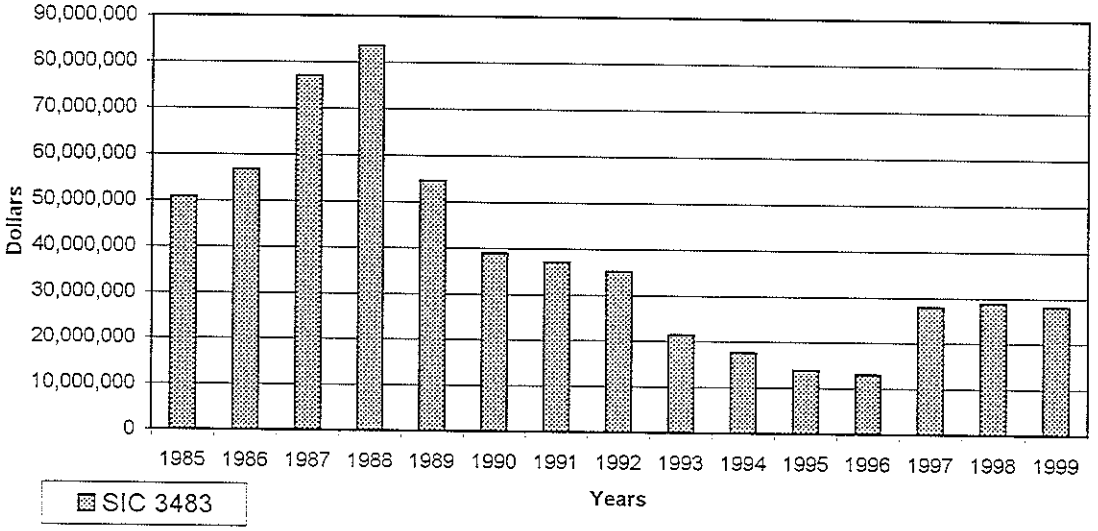
Investment Statistics from the Bureau of the Census for SIC 3483

Census Bureau data indicates that capital expenditures made by firms that produce items for SIC 3483 (ammunition over 30mm in diameter) have dropped substantially in absolute terms from 1988 to 1997. Investment per employee in this sector did not keep pace with the rest of manufacturing from 1988 to 1997.

According to the Census Bureau, since 1988 the level of capital expenditures for SIC 3483-oriented firms declined 84 percent before a modest recovery starting in 1997. **Chart 6** below illustrates capital investment in SIC 3483 from 1985 to 1999.[23]

[23] Census Bureau information is collected in actual dollars, not inflation corrected dollars. Capital expenditure data collected by the Census Bureau does not include new facilities owned by the federal government, but operated under contract by private companies. Plant and equipment furnished to the manufacturer by communities and nonprofit organizations are not included in this data. The result is that **Chart 6** shows private investment in private facilities and excludes government investment.

Chart 6: Total Capital Expenditures for SIC 3483

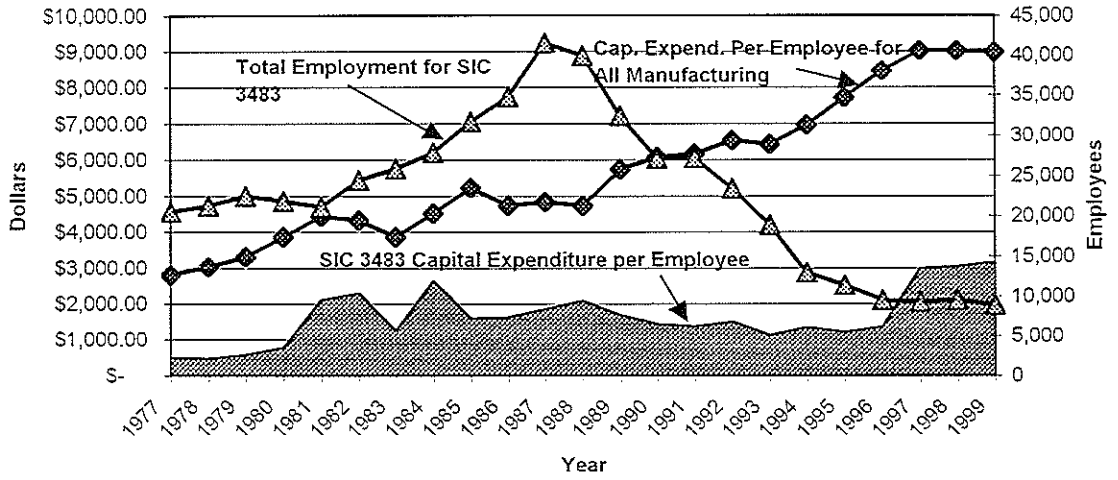


Source: U.S. Department of Commerce, Bureau of the Census

The problem is worse than it appears. While the rest of U.S. manufacturing has achieved capital expenditure growth from approximately $4,700 to $9,000 per employee for the period of 1988 to 1999, the HPEC industry's capital expenditure growth was comparatively miniscule. SIC 3483's expenditures per employee fluctuated between $1,000 to $2,000 per employee from 1988 to 1997 before increasing to approximately $3,000 per employee from 1997 to 1999.

Capital expenditures per employee have been statistically supported by the falling employment in this industry, especially since the mid-1980s. Gross capital expenditures have fallen sharply since 1988, but the accompanying declining employment numbers have masked the event, allowing perceived investment per employee to range between $1,000-$2,000 per employee. If a consistent level of employment had been maintained, expenditures per employee would have dropped steeply between 1988 and 1997 *(See **Chart** 7 below).*

Chart 7: Capital Expenditures per Employee 1977-1998
(All Manufacturing vs. SIC 3483)

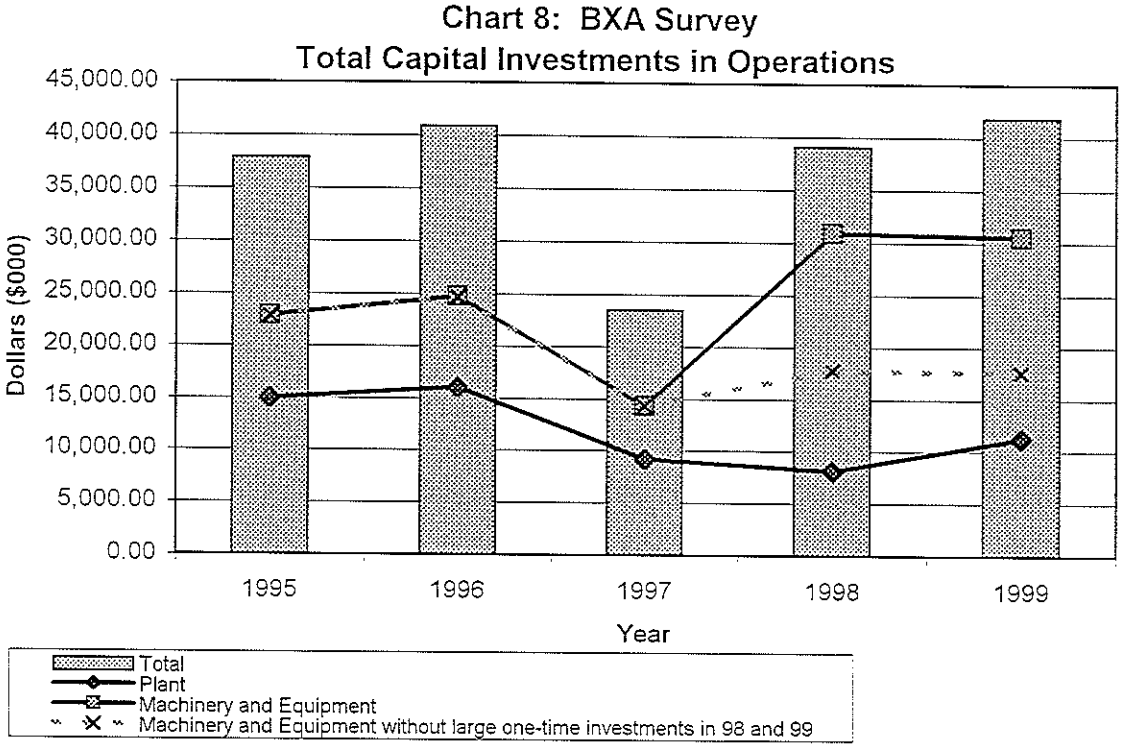


U.S. Department of Commerce, BXA Industry Survey

The modest recovery in capital expenditures starting in 1997 did raise investment per employee by $1,000 per employee. However, there were approximately 31,000 fewer employees in 1997 compared to 1988, which allowed a relatively small increase in capital spending to raise the investment per employee by 50 percent. In addition, the effect of inflation from 1988 to 1999 would also negate the effect of the increased spending in 1997.

BXA Investment in Operations Data – HPE and HPEC Industries

Twenty-seven organizations invested a total of $183 million (ranging from $23.5 to $41.8 million per year) in their operations between 1995-1999 *(See **Chart 8** below)*. Most of these outlays provided new machinery and equipment as opposed to expansion of facilities or construction of new plants. For machinery and equipment in the 1998-1999 period, most of the increase in capital expenditures can be attributed to two firms, one in 1998, and the other in 1999.



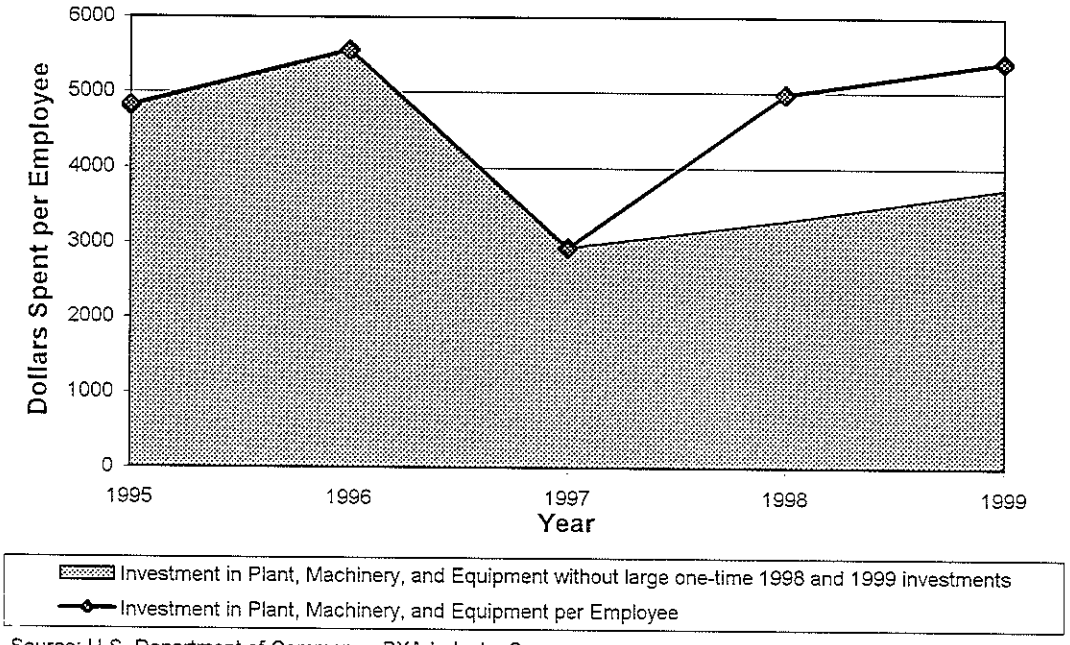
Source: U.S. Department of Commerce, BXA Industry Survey

Investment in operations, according to BXA industry survey data, was much higher than the Census numbers indicate. The investment per employee data *(See **Chart 9** below)* is, in some cases, twice as high as that found in the Census Bureau report. The most likely reason is that the Census Bureau does not count new facilities owned by the Federal Government but operated under private contract by private companies.[24]

BXA received submissions from several government-owned contractor-operated (GOCO) operations, some with substantial investments that may not have appeared on Census submissions. In addition to the possible differences in the reporting of investment figures, the universe of respondents differs. While there is overlap between the two data sets, there are also differences that may have affected the investment totals.

[24] Ammunition (Except Small Arms) Manufacturing, 1997 Economic Census, US Census Bureau Report (http://www.census.gov/prod/ec97/97m/3329g.pdf).

Chart 9: BXA Survey - Investment in Plant, Machinery, and Equipment per Employee



Source: U.S. Department of Commerce, BXA Industry Survey

Reasons for Investments in Operations

Survey respondents' capital expenditures fell into two areas: investment in plants and investments in machinery and equipment. The rationales for investments varied from company to company and in many cases companies reported multiple reasons for capital expenditures. Many investments can serve multiple purposes. For example, an upgrade in technology can add both new capability and improve productivity.

Organizations cited three primary reasons for investment in plants: adding new capability, complying with environmental and safety regulations, and expanding plant capacity *(See **Table 8** below).*

Since demand for HPEs and HPECs has declined in the past 10 years, it is unusual that expanding capacity would be one of the top three reasons for investment in plants. However, in unique instances such investments were justified. One firm won a contract that was large enough to amortize the cost of investment in capacity expansion over the life of the contract. Another was the beneficiary of a competitor's departure from the market and could justify expanding capacity. A third firm's increase in capacity was driven primarily by the need to replace old equipment, with the expansion of capacity as a secondary benefit.

Table 8: Numbers of Firms Giving Select Reasons for Investments in Operations						
Reason	1995	1996	1997	1998	1999	Total Mentions
Improve Productivity	3	3	4	4	4	18
Expand Capacity	8	6	6	6	5	31
Add New Capability	7	9	5	5	7	33
Upgrade Technology	4	4	5	4	5	22
Meet Specific Customer's Requirements	3	3	2	4	3	15
Comply with Environmental or Safety Regulations	7	6	7	7	5	32
Other	2	2	1	1	2	8

Source: U.S. Department of Commerce, BXA Industry Survey

The respondents also gave various reasons for investing in machinery and equipment. Replacement of old equipment was the most popular response, with 70 total mentions *(See **Table 9** below)*. Adding new capability was the next most popular reason, with 67 references. The third most frequent reason was upgrading technology followed by improving productivity. As with the investment in plants, respondents often chose multiple reasons for their individual investments.

Table 9: Numbers of Firms Giving Reasons for Investment in Operations (Machinery and Equipment)						
Reason	1995	1996	1997	1998	1999	Total Mentions
Replace Old Equipment	15	13	14	15	13	70
Improve Productivity	10	9	10	9	8	46
Expand Capacity	8	6	6	6	8	34
Add New Capability	16	17	12	12	10	67
Upgrade Technology	8	9	9	11	10	47
Meet Specific Customer's Requirements	4	4	3	5	2	18
Comply with Environmental or Safety Regulations	8	6	6	8	6	34
Other	0	0	1	1	2	4

Source: U.S. Department of Commerce, BXA Industry Survey

Financials

Twenty organizations provided income statement information on all operations for the years 1995 through 1998.[25] These statements included operations not related to the HPE and HPEC industries *(See **Table 10** below)*. According to the BXA survey data, the profitability of the respondents' total operations appears to be increasing.

As a group, the organizations participating in the survey saw net income for all operations increase 30 percent from 1996-1998. These companies also disclosed that the subset comprised of HPE and HPEC operations scored an increase too, but growth was less robust.

Table 10: Income Statement (Entire Firm-All Operations) Total in $000s

	1996	1997	1998
Sales	$4,277,328.7	$4,597,964.7	$4,861,202.5
Net Income	$212,489.4	$304,682.7	$305,273.4

Source: U.S. Department of Commerce, BXA Industry Survey

Eighteen organizations provided complete income statement data for their HPE/HPEC operations. The response rate was relatively low because some firms could not or would not create a balance sheet for HPE/HPEC operations. HPE/HPEC-only income statements showed that both sales and net income grew approximately 14 percent in this sub-sector (*See **Table 11** below*).

Table 11: Income Statement (HPE and HPEC Only) Total in $000s

	1996	1997	1998
Sales	$542,499.3	$569,972.0	$628,256.9
Net Income	$50,562.1	$54,686.7	$57,607.1

Source: U.S. Department of Commerce, BXA Industry Survey

[25] The survey also sought 1999 data, but several firms could not provide it. In several instances, the 1995 column contained some one-time extremes that skewed the overall trend. Data for 1995 and 1999 are excluded for these reasons. In addition, one firm that had a small percentage of its overall business in the HPE and HPEC industry was removed from the calculation due to it restructuring, which created an unorthodox balance sheet.
The number of respondents to this question was reduced further because of reporting irregularities. Several organizations that were operating units of larger firms filed separately. Organizations submitted income statement data under the parent firms. Data was consolidated and re-aggregated where feasible. Also, some other organizations did not provide data for all of three years and several could not or would not provide the data.

Asset and Liability Ratios

Twenty-three firms provided current asset and current liability data for their total organization, including all operations. Calculated by dividing current assets by current liabilities, the *current ratio* is a measure of solvency, or the ability to pay off short-term debts. The total of current assets for these industries was divided by the total of current liabilities. The total current ratio was 1.4.

The Bureau of the Census calculates current ratios[26] for all manufacturing and for broad industry sectors. From 1995 to 1999, the mean current ratio for all manufacturing was 1.35 while the current ratio for firms within SIC groups 34 and 35[27] was 1.7. The HPE/HPEC ratio of 1.4 falls in between the two Census-based ratios.

The current ratio of 1.4, calculated by combining all the firms' assets and liabilities, can be deceiving, however, because individual firm ratios ranged from 0.45 to over 20. The mean ratio calculated from the individual current ratios was 3.9; however, removing firms with current ratios of over 20 and under 0.5, the mean was 3.04. The median or middle value current ratio was 1.99, reflecting the significant range of individual firm value in these industries and their disproportionate distribution.

Seventeen of the 23 respondents provided additional balance sheets that represented their HPE/HPEC operations only. The average HPE/HPEC generated ratio for this select group was 1.34. Again, there were large differences in the individual current ratios. The mean of the individual current ratios was 3.6.

Overall, this data indicates a great deal of variation in the short-term ability of firms to cover their debts. Some firms were more than able to cover their short-term debt while others were not. Differences were observed between total firm operations and HPE/HPEC-specific operations.

[26] The Bureau of the Census calculates total current assets to current liabilities (the current ratio) in a publication called the *Quarterly Financial Report for Manufacturing, Mining, and Trade Corporations*.

[27] SIC 34 relates to fabricated metal products, except machinery and transportation equipment, while SIC 35 relates to industrial and commercial machinery and computer equipment. SIC 3483 falls into the major group SIC 34.

Research and Development

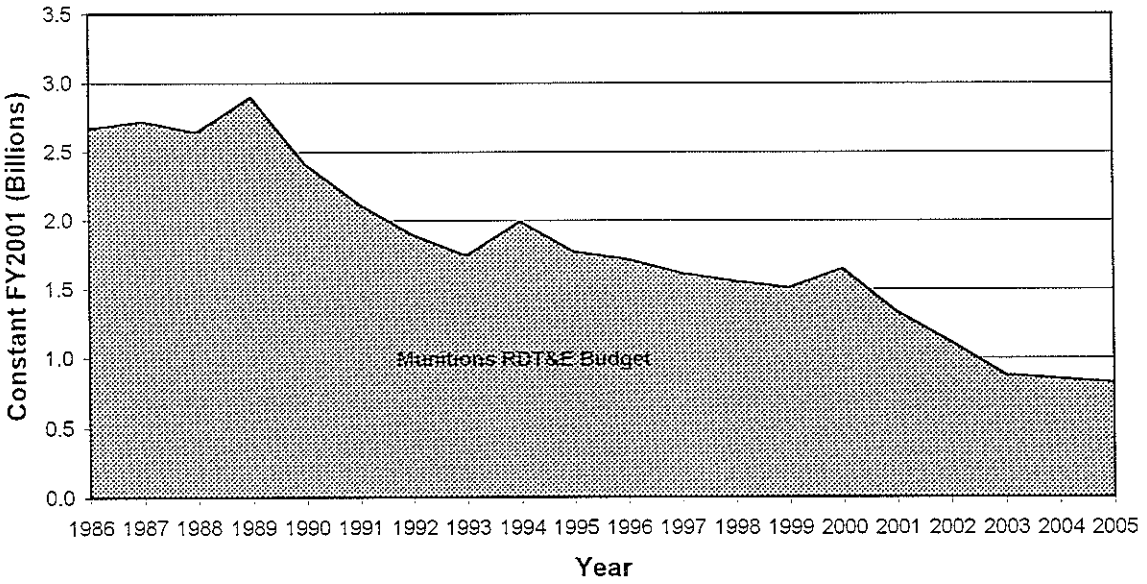
Research and development is an investment in the future. To have cutting-edge HPEs and HPECs in the future, research and development (R&D) must continue to take place at an appropriate level. For example, it can take up to 20 years, industry officials observe, to move an explosive from a blackboard formula to deploying it in a warhead.

There are requirements for new explosives or modified versions of current HPE/HPECs that can tolerate heat, shock, and other stimuli. Explosive components will also have to be designed to use these new explosives and show acceptable performance.

Department of Defense RDT&E Spending

The Department of Defense's own Research, Development, Testing, and Evaluation (RDT&E) budget numbers show that investment in munitions, which included HPEs and HPECs, has decreased rapidly since the mid-1980s and will continue to drop in the near future. Since its 20-year high in 1989, RDT&E had fallen nearly 45 percent by the year 2000. According to current projections, it will fall approximately 50 percent more, to about $820 million, by 2005. *(See **Chart 10** below)*. According to Department of Defense numbers, all of the armed services are lowering their munitions RDT&E investment. If support for R&D continues to decline, the ability of the United States to provide world-class munitions in the future could be degraded.

Chart 10: Munitions RDT&E Budget

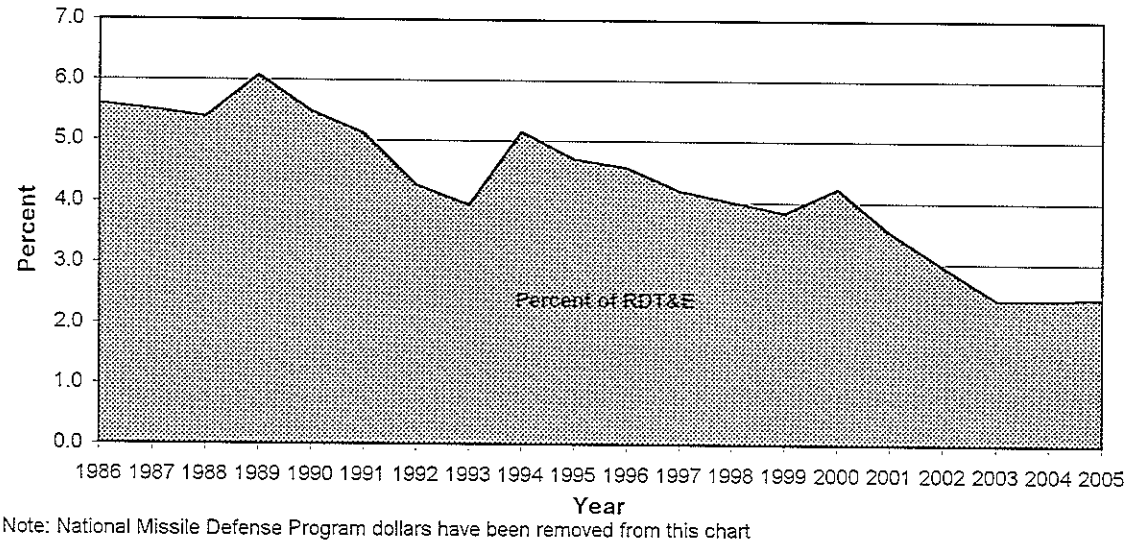


Note: National Missile Defense Program dollars have been removed from this chart

Source: Office of the Secretary of Defense (Acquisitions, Technology, and Logistics) Strategic and Tactical Systems, Munitions

What makes this issue even more serious is that munitions RDT&E is also falling as a percentage of Department of Defense's overall RDT&E budget. Munitions RDT&E was between four to six percent of the overall Department of Defense RDT&E budget from 1986 to 2000. By 2005, however, the munitions portion contracts to about 2.4 percent of the overall defense RDT&E budget (*See **Chart 11** below*).

Chart 11: Percent of RDT&E Dollars for Munitions Programs



Note: National Missile Defense Program dollars have been removed from this chart

Source: Office of the Secretary of Defense (Acquisitions, Technology, and Logistics) Strategic and Tactical Systems, Munitions

BXA Research and Development R&D Data

From 1995 through 1999, BXA survey respondents conducted approximately $154 million of R&D.[28] The U.S. Government sponsored just over 50 percent of their R&D, while survey respondents funded approximately 33 percent of the total, and non-governmental customers and foreign governments funded the remainder.

Overall, R&D funding peaked in 1996 (nearly $35 million) and decreased to $28.4 million in 1999 *(See **Table 12** below)*.[29] Likewise, by 1999 U.S. government sponsorship of R&D had slipped from a high of 55 percent in 1995 to 48.6 percent of total spending in 1999.

[28] Seventeen respondents provided R&D data. One of the larger firms submitted several surveys and consolidated some of its R&D numbers into a corporate response. Considering this point, sixty one percent of the respondents provided data on R&D expenditures. This number seems rather low; however, several of the respondents (GOCOs) appear to be build-to-print activities and do not normally engage in R&D. Some of the 17 firms were either unwilling or unable to breakdown their R&D expenditures.

[29] The domestic/foreign customer and foreign governments are combined to protect potentially proprietary data.

Table 12: Funding for R&D of HPEs and HPECs (in $000) Non-Government Sources					
	1995	1996	1997	1998	1999
Company Expenditures	10,992	11,337	9,886	9,173	9,097
Domestic/Foreign Customer and Foreign Governments	3,593	5,468	5,412	4,437	5,519
Subtotal, Non – U.S. Govt.	14,585	16,805	15,298	13,610	14,616
U.S. Government Sources					
	1995	1996	1997	1998	1999
Dept of Energy and NASA	Due to their low value and low number of projects, NASA and DOE data have been removed				
Armed Services	**17,601**	**17,627**	**15,099**	**14,679**	**13,801**
Air Force	2,775	3,300	2,240	1,810	1,110
Army	12,236	12,577	10,973	11,076	11,011
Navy	2,590	1,750	1,886	1,793	1,680
Subtotal, U.S Govt.	17,831	17,907	15,199	14,879	13,801
Total	32,186	34,432	30,397	28,289	28,417

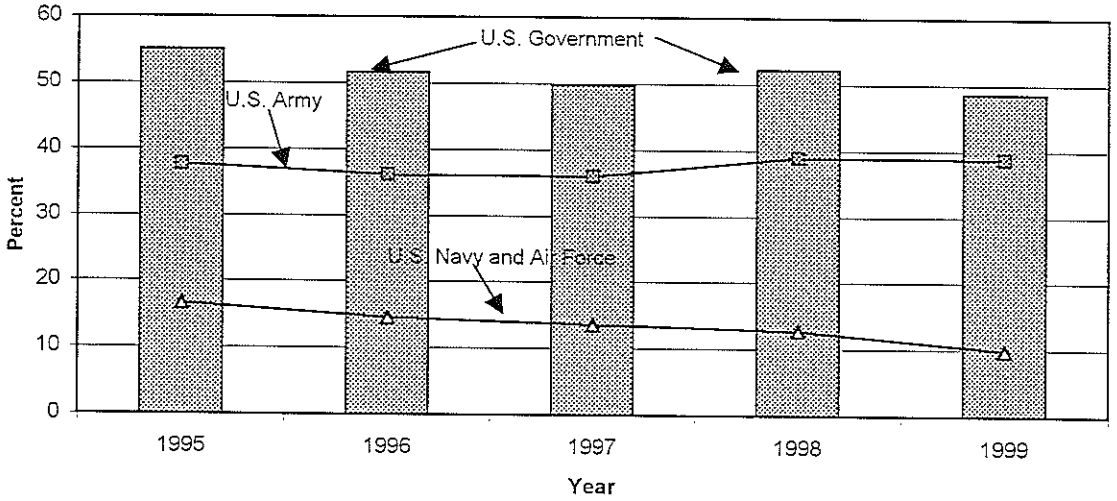
Source: U.S. Department of Commerce, BXA Industry Survey

*The above table reports expenditures by BXA survey respondents only. Government-owned government-operated R&D organizations were not surveyed as a part of this assessment.

The U.S. Army, as the largest munitions buyer, was the largest source of R&D dollars, in absolute terms and as a percentage from 1995 to 1999. The second largest source of HPE and HPEC R&D funding (running a close second to the Army) was private industry. Interestingly, foreign governments and domestic/foreign commercial customers provided more R&D funding than either the Navy or the Air Force.

Although all three services have lowered their R&D funding, the Army has maintained and even increased its percentage of R&D sponsorship. The Air Force and the Navy combined lowered their percentage by seven percent from 1995 to 1999 *(See **Chart 12** below)*.

Chart 12: HPE and HPEC R&D Funding by Federal Sources



Source: U.S. Department of Commerce, BXA Industry Survey

How HPE and HPEC R&D Dollars are Spent - Commercial vs. Defense

How R&D dollars are allocated and often spent depends on whether the project is commercial or defense in nature. The BXA survey asked respondents to categorize R&D expenditures as material, processing, or product related. Defense projects devote slightly more resources to material and product R&D *(See **Table 13** below)*, while commercial endeavors spend moderately more on processing R&D. In the commercial world, it is critical to have a well-defined process to make the product faster, better, and less expensive to produce. Defense projects are more devoted toward achieving superior product performance; thus the defense emphasis on material and product R&D.

According to NSWC Indian Head officials, the Department of Defense does not have a strong tradition of funding processing R&D. The exception is the Manufacturing Technology (ManTech) Program, which focuses on processing technology.[30] The amount of money spent on ManTech programs is small compared to the rest of the defense R&D budget.

[30] Specifically, program objectives are to:

a) Reduce the risk and cycle time associated with the transition from R&D to full-scale production by developing and implementing advanced manufacturing processes and equipment.

b) Extend the life of current Department of the Navy systems by providing manufacturing technologies to support the maintenance, repair, and overhaul of these systems.

c) Strengthen the industrial base by providing maximum dissemination of the results of all ManTech projects and the best manufacturing practices of government and commercial facilities.

Table 13: Spending Percentages of R&D for HPE and HPEC Products (Commercial and Defense)										
	1995		1996		1997		1998		1999	
	Com %	Def %	Com %	Def %	Com %	Def %	Com %	Def %	Com %	Def %
Material R&D	6.5	9.1	7.2	9.4	7.7	11.3	8.2	11.0	6.8	10.5
Processing R&D	21.4	15.8	21.9	13.8	21.8	13.7	22.8	12.0	21.2	15.8
Product R&D	72.2	75.0	70.9	76.8	70.5	75.0	69.9	77	72.0	73.7

Source: U.S. Department of Commerce, BXA Industry Survey

While processing R&D percentages in the HPE and HPEC communities seem low, they are much higher than the processing R&D percentages of the respondents' total firm operations *(See **Table 14** below)*. In addition, within HPE and HPEC operations, as distinct from total firm operations, respondents spent a higher percentage on material R&D.

Table 14: Spending Percentages of R&D for All Products (Commercial and Defense)										
	1995		1996		1997		1998		1999	
	Com %	Def %	Com %	Def %	Com %	Def %	Com %	Def %	Com %	Def %
Material R&D	4.3	5.8	4.5	6.4	6.0	5.2	6.0	5.2	5.3	5.3
Processing R&D	18.1	8.6	17.8	6.7	19.8	7.0	20.9	5.8	19.7	6.3
Product R&D	77.6	85.6	77.7	86.9	74.1	87.9	73.1	89.1	75.0	88.4

Source: U.S. Department of Commerce, BXA Industry Survey

Additional Research and Development Trends

The HPE and HPEC industries are always in pursuit of more energetic materials that can be safely used in munitions. A specific effort is underway to replace HPEs currently used in munitions with less sensitive substitutes.[31] In some cases, there may be little or no improvement in performance; rather, the benefit comes from the added safety of reduced sensitivity. The search for insensitive munitions is underway in the United States as well as other nations.

Department of Defense policy dictates that new munitions will be designed and produced to meet insensitive munitions requirements. This is also true for current weapons that are in the process of being redesigned for new missions or for greater performance. Munitions are now being configured to have vents to allow them to burn without

[31] Munitions that reliably fulfill their performance, readiness, and operational requirements on demand, but which minimize the probability of inadvertent initiation and severity of subsequent collateral damage to weapon platforms, logistic systems, and personnel when subject to unplanned stimuli.

detonating. These new or modified munitions will be less sensitive to shock, heat, and sympathetic detonation.

One respondent stated that it was trying to replace "more sensitive munitions" with insensitive and more energetic explosives. In addition, three firms stated that they were specifically trying to replace HMX and RDX explosives. These efforts could also be related to identifying and designing HPEs that would fulfill insensitive munitions requirements. Fifteen firms stated that they were using their R&D projects to design new products.

To what extent can defense and civilian R&D efforts be leveraged to enhance each other's capabilities? The respondents were mixed as to their ability to use defense R&D resources in commercial applications and vice versa. Of the 29 organizations that responded to this question, 15 said that there was little or no crossover between defense and commercial operations. This was especially true for GOCO facilities, which are defense-only operations. Often, these respondents said that they perform no commercial operations and only perform R&D when it is tied to a specific contract.

Seven organizations said that there was a significant crossover in their defense and commercial R&D. These seven organizations were HPEC manufacturers rather than HPE producers. One of these respondents stated that R&D projects are used to "increase safety, improve processes, increase capabilities and overall, to reduce financial risk." All of these objectives would apply to both commercial and defense projects. In addition to these seven respondents, four others stated that there was some crossover between their defense and commercial R&D.

Terminated R&D Efforts

HPE and HPEC manufacturers were asked to provide information on terminated R&D programs and to provide the reason(s) for termination. Seven organizations reported ending 16 R&D efforts between 1995 and 1999. Terminated R&D efforts included:

- Synthesis of explosives
- New explosives to replace current explosives
- An explosive device for a guided missile
- An explosive device for a free fall weapon

There were several reasons for terminating these R&D programs. The two most mentioned were lack of funding and competition from a foreign country. The next most mentioned reasons were the completion of the R&D project or the R&D project not being successful.

Joint R&D Projects Between Industry and Educational Institutions

An effective way to leverage research and development expertise is to collaborate with outside educational organizations. Six firms within the HPE and HPEC industries have established relationships with seven universities to undertake joint R&D. In interviews

with BXA staff, nearly all of the firms had positive comments regarding joint projects with universities.

Five of the seven collaborations that reported to BXA were funded exclusively by company dollars. Of the remaining two, one was partially funded by both the U.S. government and a firm, while one was totally funded by the government.

The motivation behind these collaborations varied from company to company. The prime attraction for these HPE and HPEC firms was that the educational institutions possessed technical capabilities and facilities that the companies needed. One firm uses universities to investigate areas that it has the capability to study but lacks the time to pursue on its own. Another firm says it taps universities because they provide good value for the dollars spent on R&D. Some firms also use educational institutions to identify students that can be hired. Most of the firms that have collaborated with universities plan to collaborate again if a worthwhile project materializes. One firm has funded research at multiple universities.

If these collaborations have been so successful, then why have only six firms participated in such programs? With declining orders and defense spending, it appears that little money is available for non-essential R&D projects. In addition, an industry representative stated that many of these relations are ad hoc and are based frequently on geography (proximity of the firm to the university). It appears that a more organized sector-wide program would be of great benefit to U.S. HPE and HPEC companies, allowing manufacturers to leverage their R&D funds.

NSWC Indian Head and the University of Maryland The Center for Energetic Concepts Development (CECD)[32]

To address the need for greater collaboration, NSWC Indian Head initiated a program to expand cooperation with universities and in turn increase the number of graduates with experience in energetics. The program began in September 1998 with the signing of a contract between NSWC Indian Head and the University of Maryland. Under this agreement both organizations are working to:

- Develop an internationally recognized energetics capability
- Develop the next generation of Department of the Navy energetics experts
- Support Department of Defense and non-military research priorities
- Access world-class experts in energetics and related disciplines
- Share experts and facilities

This program engages University of Maryland professors and graduate students in "real world" energetics projects of interest to NSWC Indian Head. The focus of this effort is to improve manufacturing technology in energetic materials. NSWC Indian Head pays for these efforts and in return its staff members can take courses at the University of Maryland, at no cost, to maintain and increase their skills.

[32] For more information, please see http://www.enme.umd.edu/CECD

In addition to training a new generation of scientists and engineers, this program also plans to train a new generation of technical workers. In the summer of 2000, the CECD received funding to begin training technicians at Maryland community colleges. This training focuses on improving the communication between engineers and technicians. Through distance learning, engineering students can see the skills technicians are learning and vice versa. This type of education should produce engineers and technicians who will know each other's capabilities and should improve their interaction.

The CECD would like to expand its efforts to include additional universities, national laboratories, and private firms. It could also be a repository of knowledge, preserving the expertise that is dispersed around the country for future generations of energetic materials scientists and technicians.

Government's Affect on the HPE and HPEC Industries

As with other industries, outside forces can affect the vitality of the HPE and HPEC industries in the United States. Two of the most important influencing factors in these industries are the U.S. Government's competing theories concerning retention of domestic capability, specifically its organic production and R&D capabilities, and the cost driven purchasing practices of the Defense Department.

The federal government plays a pivotal role in the lives of firms in the HPE and HPEC industries, influencing supply and demand. The availability of cheap imports and post Cold War DoD acquisition initiatives appear to have helped to weaken HSAAP, the largest U.S. supplier of HPEs, in the 1990s.

U.S. Government Involvement in the HPE and HPEC Industries

The federal government is, without question, the largest customer in the U.S. HPE and HPEC markets. The government also acts as a partner, competitor, and regulator. A significant number of private HPEC companies are concerned about the government's role in manufacturing HPECs and in conducting R&D. With reduced demand for these products, private companies view the government's existing HPE and HPEC manufacturing assets as a potential threat.

Historically, most of these firms have depended on defense orders to keep their highly specialized manufacturing operations solvent. Without defense orders, many of these firms would have to find new products and markets -- or go out of business. The majority of respondents said that either they have not attempted defense diversification or that their previous attempts have not been successful.

The U.S. government owns some of the largest manufacturing facilities in this sector -- many of which are operated at a fraction of their capacity. In many instances, these government facilities work as a supplier to U.S. companies fabricating munitions or act as the contractor buying components from industry. Thus, a private contractor might produce a finished warhead, but use government-furnished material in the weapon. Alternatively, a company could produce components for a finished munition, but leave the final assembly to a government-owned plant.

Survey participants verified during interviews that there is tension between private companies engaged in supplying HPECs and government-owned HPEC facilities. Some companies argue that the excess federal manufacturing capacity for HPEs and HPECs discourages private firms from establishing or expanding their own production capacity. The companies want more of what business remains allocated to them. On the other side, government-owned facilities (especially GOGOs) desire to maintain some production capacity to produce items that private industry may not choose to produce due to low production volumes; and to maintain manufacturing knowledge so it can be a "smart buyer" of munitions.

In addition to the tension between private industry and the federal government, the Defense Department is struggling with its role in managing its HPE and HPEC manufacturing base. A long standing U.S. law and a U.S. Army policy letter from 1998 appear to be in conflict regarding the use of government-owned manufacturing assets.

U.S. Law and Policy Disconnect – Government's Role in Manufacturing

The role of government manufacturing facilities in the munitions industry is not currently a settled matter within the Department of Defense. This issue has received special attention in the last several years. The role of the Arsenal Act, a long-standing U.S. law, has resurfaced to sharpen the debate on the role of U.S. government manufacturing facilities. The Arsenal Act (Title 10 U.S. Code 4532), enacted in 1956, states the following:

> The Secretary of the Army shall have supplies needed for the Department of the Army made in factories or arsenals owned by the United States, so far as those factories or arsenals can make those supplies on an economical basis.
>
> The Secretary may abolish any United States arsenal that he considers unnecessary.

In 1998, a new Department of the Army policy appears to disagree with the Arsenal Act. Industrial Base Policy Letter 98-1 is a document that seeks to "achieve efficiency" within the Army owned munitions base. Two points within this policy letter appear to conflict with the Arsenal Act. Those two points are:

> Rely on the private sector to create and sustain ammunition production assets in response to production and replenishment contracts.
>
> To the maximum extent feasible, transition government-owned ammunition production assets to the private sector while preserving the ability to conduct explosives handling operations safely.

Satisfying both documents is a difficult task. The Arsenal Act seeks to keep procurement of munitions within the organic U.S. Government industrial base while Industrial Base Policy Letter 98-1 seeks to transfer the government-owned industrial base to the private sector. As of early 2001, the Army was still composing a make-or-buy policy that will satisfy both documents.

U.S. Government R&D Capability

Beyond production activities, the federal government also relies on private companies to some extent for research and development of new energetic materials and components. Some survey participants charge that Department of Defense and Department of Energy laboratories compete with private sector R&D efforts. This has become more of an issue since federal R&D budgets have declined in real terms since the end of the Cold War, reducing the amount of government R&D funding available to industry. According to

survey respondents, federal labs also have suffered cutbacks in many instances, causing them to keep more projects in house rather than contract R&D work out to industry.

The issue the federal government confronts is how to assure that U.S. HPE and HPEC organizations maintain critical scientific and engineering knowledge for the development of explosives and weapons in both the private and public sectors. If the R&D base is allowed to atrophy, there would not be time in a moment of national crisis to train a new generation of scientists, engineers, and production workers.

In both R&D and production, companies are confronted with reduced federal support for R&D, reduced orders, and potentially aging workforces. In a climate of declining peacetime demand, attracting new talent, retaining highly valued staff, and continuing R&D on products and on manufacturing processes challenge the HPE/HPEC industries.

There is little data to demonstrate that government organizations have altered their operations in a way that is more intrusive in the HPE and HPEC markets or they have tried to monopolize R&D in the HPE and HPEC sectors. It is clear, however, that government and industry officials must devise a balanced strategy, one that maintains the operational and R&D functions of federal facilities while preserving and strengthening the capabilities of the domestic HPE and HPEC industries.

U.S. Government Acquisition Practices: HPEs

An extremely important issue within the HPE industry is how U.S. Government buyers procure HPEs for weapon systems. With the temporary closure of the HSAAP, defense programs that relied on its output began to qualify overseas HPEs for their systems. Six respondents reported 15 instances in which they imported HPEs that HSAAP had a history of manufacturing because the material was not available -- or a cheaper price could be found in another country. It is unclear if all of these programs will return to HSAAP.

HSAAP is the only manufacturing facility of its kind in terms of capability and capacity in the U.S. If HSAAP cannot count on retaining U.S. customers, the facility could travel down a rough road in the future. Low demand in peacetime could cause a loss of critical manufacturing experience due to low employment. Without an adequate level of experienced personnel, raising production quickly to meet a national need would be hampered. The acquisition officials who chose HPEs for weapon systems and the rules they followed played a role in HSAAP's troubles in the 1990s.

Program Executive Officers (PEOs), project managers, program managers, and product managers (PMs)[33] are responsible for bringing new weapon systems to life. The product manager oversees one, or several related ammunition round programs and is responsible for the development of the rounds. A project manager or program manager oversees a family of activities that reside under product managers, while the PEO oversees the activities of a group of project/program managers.

[33] Product managers, program managers, and project managers are often referred to generically as PMs. The actual title depends on the size of the specific program measured in dollars and people.

A PEO or PM has the responsibility to procure the items needed to go into a complete weapon system. In essence, the PEOs and PMs hold the purse strings to their combat systems. As high-ranking officials within the armed services, PEOs give major defense programs the visibility they need to garner support.

The PEOs and PMs for combat systems consider many factors when they source components. Examples of the types of factors that are considered include performance, risk management, cost, and industrial base concerns. The term "Best Value" is often used to describe the sum of the factors that go into a procurement decision. Many PMs are not restricted on where they buy their HPEs, so they often buy them from HPE manufacturers rather than from the U.S. Army. Under this scenario, industrial base concerns are a factor. However, industrial base advocates within the armed services and industry believe that frequently the cost of HPEs are considered more important than the industrial base implications of a foreign purchase.

There is a strong temptation to make cost a major factor in procurement decisions. There is an increasing trend in weapon systems procurements for contracts to be fixed price rather than cost plus; therefore, cost must become a priority. Under this type of system, the priority for PEOs and PMs is the system they are responsible for while industrial base issues, though considered, are secondary and perhaps minimal.

The 1990s saw a drawdown in defense spending, which lowered the volume of HPEs produced by HSAAP. The reduction in volume resulted in much higher prices per pound for HPEs, leading PEOs and PMs to look for alternative suppliers for their HPE needs. Foreign sources were qualified for U.S. weapon systems, resulting in a further loss of production for HSAAP.

This problem has been exacerbated in recent years because during peacetime, the PEOs and PMs have been influential HPEs customers. Currently, the U.S. Army is not buying bulk explosives at high rates because it has stockpiles of certain HPEs that it is reducing. The result is that weapon system program offices buy a large portion of the HPEs that are sold. The Army's Operational Support Command (the overseer/owner of HSAAP and other Army ammunition plants and a subordinate command of the Army Materiel Command [AMC]) does not have a high level of influence over these weapons programs. The PEO and PM chain of command falls under the Army Acquisition Executive and not the Commanding General of AMC. Because of this reporting structure, the PEO and PM community does not have to coordinate its efforts with the Army's industrial base community to a high degree.

This issue will most likely become less important due to the new management of HSAAP. Currently, HSAAP supplies the U.S. Army with HPEs using fixed prices, which will be in effect for the first five years under its new management. HSAAP also sells HPEs directly to weapons programs at competitive prices. With competitive pricing, there would be far less motivation to go offshore. Royal Ordnance, operator of HSAAP, is currently competing to win back the business it lost in the mid-to late-1990s as current contract cycles end and new ones begin.

The arguments for and against the foreign sourcing of munitions and their components have existed for years. U.S. HPE and HPEC manufacturers have expressed their concerns about using foreign-procured ammunition and/or components at the expense of U.S. producers. Legislation passed in 1999 addressed this issue.

Section 806 - Procurement of Conventional Ammunition

Section 806 is a portion of the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999 (Public Law 105-261). Section 806 added a critical review process to the procurement of munitions and munition components. The section addresses the purchase of ammunition from offshore sources. It states:

> (a) AUTHORITY – The official in the Department of Defense designated as the single manager for conventional ammunition in the Department shall have the authority to restrict the procurement of conventional ammunition to sources within the national technology and industrial base in accordance with the authority in section 2304(c) of title 10, United States Code.
> (b) REQUIREMENT – The official in the Department of Defense designated as the single manager for conventional ammunition in the Department of Defense shall limit a specific procurement of ammunition to sources within the national technology and industrial base in accordance with section 2304(c)(3) of title 10, United States Code, in any case in which that manager determines that such limitation is necessary to maintain a facility, producer, manufacturer, or other supplier available for furnishing an essential item of ammunition or ammunition component in cases of national emergency or to achieve industrial mobilization.
> (c) CONVENTIONAL AMMUNITION DEFINED – For purposes of this section, the term "conventional ammunition"[34] has the meaning given that term in Department of Defense Directive 5160.65, dated March 8, 1995.

This statutory language gives the position of the Single Manager for Conventional Ammunition (SMCA)[35] the authority to keep the procurement of any ammunition item or component within the national technology and industrial base[36] if the SMCA determines that a foreign procurement would have a detrimental effect of the ammunition base.

Every munitions program, regardless of service, must submit a procurement plan to the Army's Deputy for Ammunition for review. If an acquisition causes concern, then the Deputy for Ammunition is to work with the service to find a solution. If a solution cannot be found, then the issue is moved to higher levels within the Army for resolution. The ultimate authority for a decision is the Assistant Secretary of the Army (Acquisition,

[34] The definition referred to in part (c) refers to all non-nuclear munitions.

[35] The Single Manager for Conventional Ammunition (SMCA) is a position created in 1975 to organize the armed services purchases of ammunition in order to increase efficiencies. The SMCA functions are located in several locations of the U.S. Army, with the day-to-day operations located with the Operational Support Command, formerly the Industrial Operations Command. The majority of the munitions controlled by the SMCA are unguided munitions, items such as small arms, unguided bombs, and tank ammunition.

[36] The national technology and industrial base includes Canada.

Logistics, and Technology). The Army will also publish a *Conventional Ammunition End Item/Component at Risk List*, which identifies ammunition items that could be restricted.

Section 806 adds a new level of oversight over the PEO and PM community and redirects focus on industrial base issues. Since every munitions program must be reviewed, following Section 806, in theory, assists in deterring weapon systems program offices from using price as the overriding factor in procurements.

Before the effect of Section 806 could be felt, the Department of Defense attempted to radically change Section 806 to make it weaker. In early 2000, the Department of Defense sought to have Section 806 amended so that the SMCA would only be able to control procurements of ammunition and components that the SMCA actually buys for the armed services, which is approximately 25 percent of all conventional ammunition. This would have removed an important industrial base review process from 75 percent of the ammunition bought in the United States. With such a small piece of the ammunition budget, it would be difficult for the SMCA to comply with its responsibility to "maintain a facility, producer, manufacturer, or other supplier available for furnishing an essential item of ammunition or ammunition component in cases of national emergency or to achieve industrial mobilization."

Regulatory Issues Affecting the HPE and HPEC Industries

Survey respondents stated overwhelmingly that environmental and safety regulations have greatly affected their HPE and HPEC operations. Respondents claimed environmental and worker safety regulations are inflexible. The added costs incurred makes these operations less competitive than international producers that may have less stringent regulations -- a fact that the Department of Defense should take into account when making procurement decisions.

Environmental Regulations

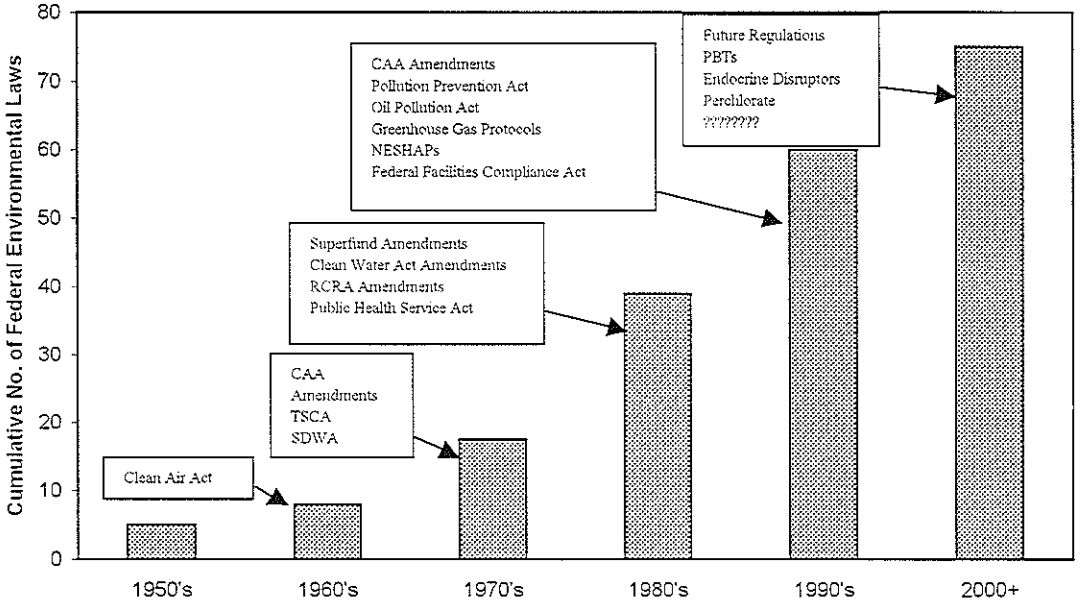
The manufacture and use of high performance explosives creates an assortment of potential problems for the environment. In many instances, the precursor ingredients are hazardous materials, as are the final products themselves.

Manufacturing HPEs creates airborne and/or water-borne wastes, and the use or detonation of the material can contaminate the air, ground, and/or ground water. To create a pound of HPE, several times that amount of waste are created in the form of spent acids and wastewater contaminated with HPEs along with other hazardous materials.

The history of these industries is not one of strong environmental stewardship. Wastes were frequently pumped into man-made ponds so they would evaporate into the atmosphere, leading to ground water contamination. Many facilities that have manufactured energetic materials are on the EPA's Superfund National Priority List.

These damaging practices occurred because there were few regulations controlling manufacturing practices. Since the 1960s, however, increasingly stringent environmental regulations have been imposed to curtail air emissions and releases of contaminants *(See **Chart 12** below)*. Today, regulations seek to prevent hazardous material releases through the ground, air, and water.

Chart 13: Growth of Environmental Requirements



Source: The Energetic Materials Environmental Study, SERDP

HSAAP not only produces HPEs, but also produces the precursor chemicals needed to make the HPEs. As a result, it generates of wastes that are regulated by the Environmental Protection Agency. The Energetic Materials Environmental (EME) study[37] published in 1999 included the totals from HSAAP's most recent EPA Toxic Release Inventory *(See **Table 15** below)*.

[37] The Strategic Environmental Research and Development Program (SERDP) published an extensive report, *Energetic Materials Environmental Study* (EME study) that details the current state of the energetic materials community. SERDP is a Department of Defense organization that works with the Department of Energy and the Environmental Protection Agency to conduct environmental R&D. Its goal is to "minimize or remove major negative environmental impacts on DoD's ability to conduct [its] mission." For more information please see http://www.SERDP.org

The EME study covered the entire energetic materials community (explosives, propellants, and pyrotechnics). The objective of this November 1999 report was to provide SERDP and other organizations with a comprehensive description of the present environmental state of the energetics community and to provide background information for an assessment of how conditions might change in the future. This report focused on operations at government-owned facilities; however, commercial operations were also examined.

Table 15: Holston Army Ammunition Plant 1996 Toxic Release Inventory (In Tons per Year)			
Chemical	Air	Water	Total
Ammonia	0.37	0.81	1.18
Methyl Ethyl Ketone	13.78	3.15	16.93
Nitric Acid	0.48	0	0.48
Nitrate Compounds	0	99.64	99.64
Total	14.63	103.61	118.24

Source: Energetic Materials Environmental Study, SERDP

HPEC facilities engaged in load, assemble, and pack operations also create waste materials in the process of loading HPEs into warheads. Waste is generated from scrap explosives, open burning, open detonation, and other sources, such as solvents for machine cleaning and lubrication oil, according to the EME study.

As time goes on, U.S. HPE and HPEC plants may have to reduce emissions further. Activities tolerated at HSAAP and other facilities under current regulations today may not be acceptable in the future.

The EME study found that, "generally speaking, the commercial industry sector of the energetic community has been more responsive in addressing environmental issues. The DoD industrial base has not begun to fully address these issues and tends to approach them [largely] by a reactive, last minute manner."

The HPE and HPEC industries, including both government and private producers, may benefit from emulating some of the best management practices now being employed by manufacturers such as DuPont and Department of Energy national laboratories. These organizations are working to create production systems that minimize the release of pollution from the beginning of the process rather than depending on end-process waste stream clean-up systems.

At the same time, HPE producers should be looking at new manufacturing processes that can dramatically reduce production wastes and associated environmental management requirements. Specifically, the EME study urged that the industry pursue greater use of chemical modeling tools for designing new HPE production processes. "Such technology should be considered a logical and necessary step in the strategic development of new energetic materials," said the report.

BXA Survey Environmental Data

According to BXA survey respondents, the environmental regulation that most frequently affects their operations is the Clean Air Act. Originally enacted in 1970, the Clean Air Act has steadily been expanded. Unintended consequences of the law have been increased operating costs and decreased competitiveness of U.S. manufacturers of HPEs and HPECs.

Twenty-four organizations reported spending an average of $15.6 million a year from 1995 to 1999[38] on environmental, OSHA, and other federal and state regulations. These respondents devote approximately 1.5 percent of their workforce to environmental compliance and safety functions.

Survey participants also reported that environmental regulations have reduced the flexibility of their operations. The most frequent example (three mentions) of curtailed or restricted activities was the burning of scrap explosives in a "burn pit." This scrap is now treated as hazardous waste and the cost for disposal is much higher, according to respondents.

Differences in State Regulations

Five respondents noted that there were significant variances in regulations across the states. Even where regulations are not dramatically different, their interpretation can differ greatly. One firm reported that in some states, its waste products are classified as hazardous wastes, but in others, it is able to dispose of waste material differently and at reduced costs.

[38] The BXA survey asked respondents for the total amount of money spent on " meeting federal, state, environmental, OSHA and other regulations over the past five years." Therefore, the environmental numbers alone could not be extracted.

Other Issues Affecting the HPE and HPEC Industries

Trade issues are another area of concern within the HPE and HPEC communities. According to the survey respondents, both HPEs and HPE processing equipment have been imported into the U.S. from 1995 to 1999. In the case of HPEs, material imports included products that have a history of production in the U.S.

One way that HPEC manufacturers are coping with reduced U.S. defense spending is to focus more on exporting their products to other nations. Foreign defense firms are also employing this strategy to increase their business base for both HPEs and HPECs.

Foreign defense manufacturers are targeting the U.S. because it is the largest defense market in the world. Meanwhile, U.S. government export licensing issues and conditions imposed by foreign buyers and/or their respective governments hamper U.S. companies in their efforts to sell products overseas. These conditions include imposing defense trade offsets on U.S. sales overseas.

Imports of HPEs and Manufacturing Equipment into the U.S.

In the mid- to late-1990s, imports of HPEs into the United States increased primarily because of the high costs of HPEs produced at HSAAP, its shutdown, and change of contractor. BXA survey data indicate that HMX and RDX account for most of the HPE materials imported into the United States during this time. Both HPEs are produced at HSAAP, and there is no alternative U.S. source for large amounts of these products. Without HSAAP's contribution to the HMX/RDX market, replenishment of munitions inventories could not be accomplished in three years.

With HSAAP's reopening in the summer of 2000, import levels should drop. However, the reopening may not immediately force a major cutback in import levels. Imports of foreign material could continue due to established relationships created with foreign suppliers, competitive prices, and the use of HPEs in defense offset transactions.

Sweden's Bofors Explosives and Norway's Dyno Industrier were the prime sources of imported HPEs from 1995 to 1999. Other nations that export HPEs, for defense and limited commercial applications, to the United States are the United Kingdom, China, Israel, Slovakia, and Romania. The most common reasons cited by American firms for buying imported raw materials were the lack of a known domestic source, a desire to secure a second supplier to a domestic manufacturer, and/or lower cost.

As for the positive and negative effects of importing finished HPEs, survey respondents had varying views. Survey data show that the organizations that use HPEs as a raw material or as a subcomponent were much more positive toward imports than organizations that produce HPEs. The majority of respondents said that imports had no effect on their operations or that imports simply are not applicable. Eight respondents stated that imports offered lower prices, reflecting that the price per pound of HPE products produced at HSAAP rose steadily in the mid-to late-1990s. Thirteen of twenty-two firms that responded to a question regarding the negative effects of imports asserted

that there were no negative effects from imports or that imports were not applicable to their business operations.

In contrast, nine organizations acknowledged negative impacts. These respondents reported having difficulty competing against foreign manufacturers. They charged that overseas companies receive unfair government subsidies and operate under less stringent environmental and safety regulations. In addition, two U.S. companies commented that they experienced longer-than-normal lead times with foreign-produced HPEs -- and at times had difficulty obtaining the material.

Imports of Manufacturing Equipment

Another area of concern within the HPE and HPEC industries is the importation of key manufacturing equipment. U.S. firms imported two types of manufacturing equipment from 1995 to 1999 because of limited or non-existent U.S. sources. The two types of equipment were nitration equipment and mixers.

Nitration: the Process and the Equipment – Nitroglycerine

Nitration of glycerin occurs when glycerin is reacted with a mixed acid solution containing nitric and sulfuric acids. The glycerin and the mixed acids are reacted in an agitated vessel that contains cooling coils to control the exothermic (heat generating) reaction. The solution then travels to a separator to separate the nitrated glycerin and the spent acid. The remaining steps include the washing of the nitrated glycerin and finally the neutralization of the remaining acid with a basic solution to create the final product, nitroglycerine.[39]

Nitroglycerine is manufactured by either a batch or continuous process. In a batch process, the ingredients and products go though each step as a single mass. In a continuous process, the ingredients and products flow through the system constantly so each stage is performing its function throughout the process run. This results in a constant stream of product flowing through and out of the system.

Continuous processing has the advantage of being safer because less material is in the process at any one time compared to a batch process. The continuous method is the most popular nitroglycerine processing method in United States. However, because there is no manufacturer of continuous nitration equipment in the United States, the equipment must be procured overseas. The most well known manufacturers of this equipment are all located in Western Europe.

[39] Nitroglycerine is not used as a military explosive due to its high sensitivity. Rather, it is used as an ingredient in propellants. However, nitroglycerine has been used as an explosive in civil applications. It is most well known civil application is dynamite. In dynamite manufacturing, nitroglycerine is absorbed in wood shavings. The wood shavings reduce the formation of microscopic bubbles in the nitroglycerine, which increases its sensitivity.

Mixing Equipment

Mixers combine energetic materials in preparation for pouring or injecting them into finished munitions or rocket motors. Many melt-cast/cast-cured warheads and rocket propellants are combinations of multiple ingredients -- and the mixture of those ingredients needs to be uniform in order to achieve maximum performance. One example of such an explosive is Composition B, which is composed of RDX crystals mixed into molten TNT. Firms that specialize in rocket propellants also have much of the equipment needed to cast explosive warheads.

Mixers come in many sizes, ranging from one-quarter gallon to 600 gallons. These mixers are similar to those found in other industries, such as the food processing industry, but they are more robust in their design to meet the needs of energetic material manufacturers. These mixers have remote operation capability and are fitted with fire detection/extinguishing equipment. A mixer can last for 20 years with proper maintenance before it would need a rebuild.

Currently, there is one U.S. manufacturer of purpose-built energetic vertical mixers. Since there are few companies who make spare parts to repair in-service vertical mixers, some firms have had to reverse engineer spare parts to keep their equipment in operation.

HPE and HPEC Manufacturers Response to Overseas Supply Interruptions

HPEC suppliers were asked if they encountered delays in shipments or other disruptions in HPE material deliveries from foreign suppliers, how their operations were affected, and how they responded. Several organizations reported that should a serious production disruption occur, they might have to identify, develop, and test an alternative material. Any serious delays in shipments would push back deliveries of completed products by many months because the substitute materials would have to pass qualification tests.

There appears to be some debate about the reliability of some foreign supplied HPEs. Three respondents have found offshore HPEs to be of equal or higher quality than U.S.-made products. Two other organizations, however, reported that foreign materials did not perform adequately. In one instance, the material had to be reprocessed before it met specifications.

The prospect of encountering delays in procuring critical materials and uncertainty about consistent quality suggests that the United States must maintain adequate HPE production capacity even if DoD decides that it can rely on foreign vendors on a long-term basis to fill some of its requirements.

U.S. Exporters Face Hurdles

American HPEC companies seeking to expand their presence in overseas markets have been restricted by regulations at home as well as conditions imposed by foreign customers. Five survey participants reported having problems exporting, chiefly because of export licensing issues.

To lessen competitive disadvantages that U.S. firms face in exporting their HPE/HPEC products, some survey respondents urged that changes be made to achieve uniformity between the Departments of Commerce and State concerning licensing issues. [40] Other suggestions included requiring faster turnaround times for export licenses and loosening export restrictions on exports and technology transfer.

U.S. organizations also must overcome barriers to trade erected by foreign countries. In one instance, a foreign nation stipulated that its vessels must be used for shipping. As a result, shipping delays can occur, which increase costs and reduce cash flow for U.S. manufacturers.

A far more onerous and thorny problem faced by U.S. HPE and HPEC companies is demands for offsets in defense trade made by foreign companies or their governments. Offsets are mandatory industrial compensation practices that can hurt the health and competitiveness of U.S. defense suppliers, particularly at the subcontractor level. Offsets are required as a condition of purchase in either government-to-government or commercial sales of defense articles and/or defense services as defined by the Arms Export Control Act and the International Traffic in Arms Regulations.[41] Examples of offset activities include co-production, licensed production, technology transfer, purchases, investment, and training. In most cases, prime contractors, not their suppliers, sign offset agreements.

Many executives within the defense subcontractor base as well as government policymakers see offsets as a form of extortion and contend that the practice distorts market forces within the defense supply chain. In many countries, particularly in Western Europe and Canada, mandatory offsets equal 100 percent of the export sale value. While the BXA survey did not contain any questions that focused on offsets, four respondents mentioned offsets in various places in the survey.

One firm that participated in BXA's survey said that offsets made selling HPECs overseas much harder. Western European countries, it noted, require offsets when the contract is valued at over $5 million dollars. A U.S. manufacturer of munitions also disclosed that, in a number of foreign countries over the next five years, it may be forced to use foreign-made HPEs in its finished products in order to land supply contracts. Another American manufacturer stated that in one particular competition it was competing in; it had a lower price but lost the sale. The U.S. defense contractor chose to buy the product at a higher price in a foreign market to satisfy an offset agreement.

[40] The Departments of State and Commerce are responsible for export licensing issues. The State Department oversees licenses that are military in nature only. The Commerce Department oversees commercial items and dual-use items. Other government departments, including the Department of Defense, have input into the export licensing process.

[41] The offset definition was derived from the yearly BXA publication, *Offsets in Defense Trade*. This report is furnished to Congress under section 309 of the Defense Production Act of 1950. For more information, please see http://www.doc-bxa.bmpcoe.org/odtir.html.

According to survey participants, the costs of offsets are felt throughout the entire U.S. supply chain. Not only are U.S. prime contractors directly involved, but their subcontractors often bear a large portion of the offset burden. "Offsets tend to hit the subcontractors and small businesses, not so much the primes," explained one U.S. manufacturer. Offsets that are agreed to by prime contractors (i.e., large defense contractors) are often pushed down to the prime's subcontractors for fulfillment.

The cost to American firms in fulfilling offset requirements often runs much deeper than the loss of a single order. U.S. subcontractors at times are effectively forced to assist in constructing another production line in a purchaser's country, to transfer some other kind of technology to the purchasing nation, or to provide some other form of compensation (investment or non-related purchases).

Because they lack leverage, U.S. subcontractors are in a difficult position to change these conditions. Usually, subcontractors are instructed to meet these offset obligations by their primary customers, the prime contractors, who they do not want to alienate.

Canada's Special Access

Another area of concern for U.S. HPE and HPEC producers is the market access that Canada enjoys in the United States. Canada is considered a part of the U.S. national technology and industrial base, which means that a Canadian companies can compete for U.S. defense contracts as if they were an American company. No other country has this special access to the U.S. defense market. Canada, on the other hand, does not have a reciprocal policy.

The Canadian government also goes to great lengths to assist its companies in selling their products overseas. The Canadian Commercial Corporation (CCC) is a government-owned organization that assists Canadian companies in making export sales around the world. The CCC assumes legal risk for Canadian companies and acts as a prime contractor for Canadian firms. One survey respondents stated that the CCC performs many marketing and contract administrations functions for Canadian companies at no charge while a U.S. firm would have to pay for these services either internally or externally.

The CCC is adept at gaining access to the U.S. defense market. The CCC advertises its ability to find defense sales opportunities in the United States and helps Canadian companies secure sales. The CCC is so successful that the U.S. Department of Defense endorses its activities. The CCC states that, "at the request of the U.S. DoD, all purchases from Canadian companies over $100,000 must be contracted through CCC." The U.S.-based Munitions Industrial Base Task Force states that a 1978 Canadian Government decision restricts the procurement of munitions to Canadian companies if they have the ability to produce the item. In the event that the Canadian industrial base cannot make the item, U.S. firms do not have special consideration.

U.S. munitions companies have even been excluded from Canadian defense orders. This occurred in the late-1990s when Canada was interested in procuring a 105mm high-

explosive extended range artillery round. A U.S. firm, which was part of a team manufacturing such a round for the U.S. military, approached the Canadian government and asked to make a bid for their needs. This firm was told that it could not bid on the item. The U.S firm asked for assistance from the Department of Defense, which in turn contacted the Canadian government. In the end, the U.S company was allowed to bid; however, a paper design from another country was selected as the winner.

Canada also requires defense trade offsets from U.S. defense contractors. Canada has one of the more aggressive programs in the world, requiring that 100 percent of the value of the contract be represented in the offset program. In other words, if the value of the contract is $10 million dollars, then the contractor must create $10 million of benefit for the Canadian economy through technology transfer, subcontracting, or other forms of compensation. Almost all Canadian government-mandated-offsets are commercial in nature (economic development) and have little to do with the defense item being purchased. The United States does not have such a policy toward Canadian companies.

In 1996, the U.S. Department of Defense and the Canadian Department of National Defense signed a Memorandum of Understanding regarding defense procurement. The agreement was to assure equal treatment for U.S. and Canadian companies. Unfortunately, it appears that since this agreement, little has changed in the level of access for U.S. munitions companies in Canada.

Surge Capability – Bottlenecks to Operating at Full Production

With the demise of the Soviet Union, the need for defense manufacturers to mobilize and increase their production in a time of crisis has dissipated.. However, shortages of defense items have occurred since the end of the Cold War. An example of such a phenomenon was the near-exhaustion of the Conventional Air-Launched Cruise Missile (CALCM) supply during the Kosovo conflict. Numerous other items required priority ratings to increase production levels. The ability to increase production rapidly is still important to the U.S. industrial base and national security.

Considering this continued need, BXA asked HPE and HPEC firms to identify the top three factors that would prevent them from operating at full production capacity.[42] Survey participants cited the availability of raw materials as the most frequent obstacle to achieving and maintaining full production *(See **Table 16** below)*. However, in terms of cost, the most serious problem in increasing production rapidly and sustaining it could be

[42] The Bureau of the Census defines full production capacity as the maximum level of production that an establishment could reasonably expect to attain under normal operating conditions. In estimating full production, firms are asked to consider the following: (1) Assume only the machinery and equipment that is in place and ready to operate will be utilized. Do not consider facilities or equipment that would require extensive reconditioning before they can be made operational. (2) Assume normal downtime, maintenance, repair and cleanup. (3) Assume number of shifts and hours of plant operations under normal conditions are not higher than that attained by a given plant any time during the past five years. (4) Assume overtime pay, availability of labor, materials, utilities, etc., are not limiting factors. (5) Assume a product mix that was typical or representative of production during the last quarter. If the plant is subject to considerable short-run variation assume the product mix of the current period. (6) Do not assume increased use of productive facilities outside the plant for services (such as contracting out subassembly work) in excess of the proportion that would be normal during the last quarter.

Table 16: Top Five Bottlenecks to Full Capacity Production			
Bottleneck	Number of Mentions	Average Cost to Correct	Average Number of Weeks to Correct
Raw Materials Availability	12	$517,500#	22.5
Availability of Expertise	9	$179,200	21
Other Materials Availability	8	$1,741,000*	28.8
Labor Availability	7	$120,800	13.1
Labor Costs (Training)	6	$498,000	18

Source: U.S. Department of Commerce, BXA Industry Survey

#One firm reported a multimillion-dollar cost for correcting the bottleneck, which raised the average significantly.
*One firm reported a multimillion-dollar cost for correcting the bottleneck, which raised the average significantly.

the availability of finished materials, components, and machinery, where long-lead times may be encountered.

According to survey respondents, almost as important as the availability of raw materials and other critical materials is the availability of technical expertise across a range of disciplines. Other potential limits on increasing production include labor training costs and the availability of general labor.

Closed/Mothballed Plants and Restart Requirements

According to survey participants, the challenges confronting companies and the Defense Department in ramping up production in a national emergency could be substantial. The mean time needed to restart facilities judged to be capable of being restarted is almost one year.

Why such a long time for restart? BXA's survey shows that not all manufacturing organizations spend funds to keep inactive production lines in operating condition. Only six of the 33 surveyed organizations indicated that they maintain idle equipment. The mean cost across the five respondents that provided expense data was approximately $175,300 per year.

The extent of HPE and HPEC production unit retirements in the United States from 1995 to 1999 was substantial. Slack demand was cited as the chief reason for eight organizations closing eleven operations, the majority being production lines rather than entire facilities. The mean percentage of capacity shut down per firm was 34.7 percent.[43]

[43] The percentage of capacity shut down was self-defined.

Six of the eleven closings occurred in 1995. Thirty-six percent of these 11 companies said that their production lines or plants could not be restarted.

Diversification in the HPE and HPEC Industries

One way defense companies have chosen to keep themselves viable during low periods of defense spending is to diversify their operations. Companies enter into commercial markets to lessen their dependence on defense orders.

Of the 26 defense diversification question respondents, half stated that they were successful while the other half had discouraging experiences with diversification -- or had not attempted it at all.

Respondents with positive diversification experiences have moved into markets such as automobile air bags and cartridge- and propellant-actuated devices. Several government-owned contractor-operated (GOCOs) facilities have diversified by working with the Armament Retooling Manufacturing Support (ARMS) program. This program provides incentives for commercial businesses to relocate to the grounds of GOCO ammunition plants.

The majority of firms that had discouraging experiences or that did not attempt diversification said that their processes, equipment, and/or facilities are optimized for military products and are not compatible with civilian activities. This is especially true for GOCOs, whose facilities are built for high-volume munitions work. One GOCO participant stated that manufacturing commercial products efficiently was difficult because its facilities had too many small buildings spread too far apart.

Shortages Experienced by U.S. Munitions Manufacturers - 1995-99

Even in peacetime, munitions manufacturers encounter significant, if not disruptive, shortages of critical materials and components. Fifteen respondents to BXA's survey disclosed that they experienced twenty-six shortages of necessary production process materials between 1995 and 1999.

The most frequent shortage involved specific HPEs or HPEs in general (10 mentions). Lead azide, which is used as an initiating explosive in munitions, was the material most frequently cited as at times being difficult to obtain.

U.S. HPE organizations have responded to such HPE shortfalls by either finding and qualifying another source, or purchasing the material from available U.S. government stocks. Survey respondents reported shortages for 17 other materials as well. Examples of these shortages include chemicals for HPE manufacturing and metal parts for HPECs. These were one-of-a-kind events, however, that were not a problem for these industries. All but one of the shortages was solved, usually by making design changes to products, or by finding new vendors for the materials.

Recycling of HPEs – Future Opportunity and Challenges

The recycling of explosives is a possibility that could greatly affect the HPE industry. If an economical way of recycling HPEs extracted from munitions and rocket motors can be found, then a new and potentially large supply would be available. The concept of recycling materials could solicit support from many sides.

U.S. Government policy is making use of recycled materials a more important part of its procurement practices. Executive Order 13101, signed by President Clinton in September 1998, states "each executive agency shall incorporate waste prevention and recycling in the agency's daily operations and work to increase and expand markets for recovered materials through greater Federal Government preference and demand for such products."

In response to this Executive Order, the Under Secretary of Defense for Acquisition and Technology, Jacques Gansler, distributed a memorandum in December 2000 that reinforced Executive Order 13101 and stated that the munitions demilitarization stockpile should be viewed "as an asset instead of a liability and use it to maximize resource recovery and reuse."

The United States currently does not manufacture some explosives, one example being TNT[44], and would potentially benefit from a recycled domestic source. In addition, explosives manufacturing uses a variety of environmentally hazardous chemicals. Using current explosives rather than creating new material would help reduce environmental risks and damage.

Not many of the survey respondents salvage explosive materials from surplus munitions; however, a third of the survey participants stated that they were interested in examining the concept to see whether it is practical. Specifically, eleven respondents expressed interest in recycling HPEs. Conversely, two respondents stated that HPE recycling would hurt their business base. Overall, the respondents were positive toward the concept.

Company opinions on recycling were qualified by a variety of factors however. One of the points most frequently mentioned was that the recycling of HPEs would have to be done on a case-by-case basis. Each formulation is different and stringent specifications would need to be followed to ensure that the recycled material would perform the same as virgin material.

Some respondents stated that recycling HPEs may not be economical compared to newly produced HPEs. One respondent stated that the "techniques for recycling to produce economically viable products [from the myriad of explosives & components] do not yet exist, and DoD R&D funds are inadequate to fully explore the potentials."

[44] The U.S Army is currently studying how to address a shortage of TNT that will occur in the next several years. One of the options is to reuse or recycle TNT from obsolete munitions. It is yet to be determined if the reclaimed material will be suitable for reuse.

Another side to the recycling story could become an important factor in deciding whether HPEs should be recycled: recycled material could compete with new production HPEs.

Currently, there are several programs underway to find ways to recycle HPEs. TPL, Inc. of New Mexico is testing a process that recovers HMX from LX-14. Alliant Techsystems's Thiokol Propulsion unit is developing a process that will pull HMX out of ballistic missile rocket motors at a price that may compete with new production HMX. In the case of recycled HMX from ballistic missile rocket motors, the amount of potential recycled material is in the millions of pounds. This potential reserve of HMX could supply the U.S. with its peacetime HMX needs for many years.

All of these processes are in development and are several years from becoming full-scale production processes. The HPEs from recycled material would have to be qualified for military systems. These potential options may give users of HPEs an alternative U.S. source. Producers of HPEs, especially HSAAP, could find it difficult to compete against recycled HPEs.

Taggant Use in High Performance Explosives

Terrorist attacks on military and civilian facilities over the past 20 years caused western countries to call on manufacturers of HPEs to blend taggants into their materials. Taggants are marking agents that identify the explosive used after detonation. Taggants assist law enforcement agencies in tracing the source of explosives materials used in terrorist attacks.

Four organizations responded that they have been required to add taggants to their products. Of those four, three of them stated that using taggants has not significantly affected the way they do business. One firm said that using taggants increased the cost of production, an expense passed on to customers, but did not dramatically affect the way it does business.

In contrast, another respondent stated that the use of taggants did have a significant affect. This respondent stated that the taggant it used was expensive and that the use of the taggant required the organization to purchase additional equipment to work with it.

International Assessment

International firms pose a competitive threat to the U.S. HPE manufacturing base. European manufacturers see the United States as an important, and in some cases, growing market for their products.

Moreover, from a competitive standpoint, European firms are well positioned to go after U.S. market share in both the American and international markets. From an economic standpoint, European manufacturers may have a competitive edge because their production facilities are better sized for the current peacetime HPE demand than the United States' Holston Army Ammunition Plant. In addition, other factors such as a strong U.S. dollar and potentially lower environmental standards and costs have made foreign-produced HPEs attractive to U.S. purchasers.

In terms of meeting U.S. national security requirements in a time of emergency or war, however, European facilities cannot compete. Not only are these foreign supplier plants separated from the United States by considerable distance, but also their facilities lack significant surge capability. HSAAP, in contrast, has the capability to meet replenishment obligations required by the Department of Defense.

BXA sent copies of the HPE and HPEC survey to selected foreign manufacturers.[45] Royal Ordnance (an operating unit of BAE Systems) of the United Kingdom, SNPE of France, and Dyno Industrier of Norway returned surveys to BXA in various levels of completeness.

As a part of its assessment, BXA staff also visited selected international manufacturers. Royal Ordnance, Nexplo Bofors of Sweden, Dyno Industrier, and ADI Limited of Australia provided briefings on their operations.

The United Kingdom's munitions industry (specifically Royal Ordnance) appears to be the most similar to the U.S. in that it has a munitions base that was sized for the Cold War environment. Developed in response to World War II, as in the United States, this munitions base was spread out geographically to limit the vulnerability of manufacturing facilities to German bombers. In an effort to become more competitive, Royal Ordnance is shifting and consolidating its facilities in the United Kingdom.

SNPE may have similarities to the U.S. industry. However, neither a site visit nor extensive one-on-one interviews were conducted with SNPE.

Shipments

Due to the level of survey completeness, the shipment numbers for the three foreign firms are difficult to compare. For example, one firm did not provide its shipments in units.

[45] Topics covered in the discussion on foreign firms are centered on data points that the three survey respondents answered completely. As a result, some aspects are unsuitable for comparisons. There were areas, however, where comparisons between the foreign manufacturers and U.S. manufacturers can be made. Where appropriate, information collected from site visits is included.

This same firm did not provide data for 1999, while another did not provide data for 1995.

From 1996 through 1998, two of the international firms' production of HPEs slowed. One firm's production was down 6.4 percent and another firm's production dropped 8.2 percent. The third firm, however, increased its production 6.1 percent.

Competitive Assessment of Foreign Firms

Foreign firms have different opinions concerning their competitive situation for the next five years *(See **Table 17** below)*. Two firms stated that their overall competitiveness would improve somewhat or greatly. The reasons behind these statements included technology leadership in specific types of explosive applications, cost reductions, and access to new production facilities. One manufacturer felt its competitive position would not change and said that its capabilities were strong. However, the company acknowledged that foreign competition was not going to disappear.

Table 17: Non-U.S. Company Competitiveness Outlook

	Improve Greatly	Improve Somewhat	Stay the Same	Decline Somewhat	Decline Greatly	Not Applicable
Overall Competitiveness	1	1	1	0	0	0
Home Market Competitiveness*	0	0	1	0	0	1
Worldwide (International) Competitiveness	1	1	0	1	0	0

Source: U.S. Department of Commerce, BXA Industry Survey
* One firm did not answer the home market competitiveness question

In terms of home market competitiveness, one foreign firm expressed no opinion, another said that it was not applicable, and the third stated that its domestic competitiveness would stay the same. The company noted that it had little domestic competition.

In terms of international competitiveness, one foreign firm said it was improving greatly while a second firm reported that its world-wide competitive posture had improved somewhat. A third firm said its position in the global market place had declined somewhat.

The reasons for some companies' optimism include strong product lines and access to new facilities. The firm that reported that its competitiveness would decline somewhat stated that with the resumption of operations at HSAAP, the U.S. market would become more competitive.

The three international firms that returned surveys (BXA staff visited two of those three) and an additional company that BXA staff visited indicated that they were working on new HPE products. The types of R&D projects underway are similar to U.S. projects and include HPEs that U.S. firms are developing. Current R&D efforts by foreign firms also include increasing the performance of existing explosive products while reducing sensitivity and finding energetic binders and fillers for munitions.

Employment Issues

With regard to workforce issues, non-U.S. survey respondents expressed some of the same concerns as U.S. firms. One foreign firm stated that even with training programs, it was having difficulty maintaining critical skills with a shrinking workforce.

Two non-U.S. firms projected future labor concerns. Again, maintaining critical skills was the theme of their responses. One overseas HPE supplier was initiating a program to "secure transference of know-how between generations" and to keep skilled personnel at all levels of the company. To address future labor needs, one company said that it would hire and train new employees to replace lost employees. Another foreign manufacturer stated that it would work to create multi-skilled employees to give the company more production flexibility.

Investment in Operations

In general, foreign firms make new investments in their operations for many of the same reasons U.S. firms do. However, survey results indicate that the investment priorities of these firms may differ at times from those of American HPE and HPEC companies.

In the case of investment in production plants, the reason most cited by foreign manufacturers was to upgrade technology. This response suggests that the three respondents are interested in process refinements for existing product lines that will enable them to lower costs and improve profit margins.

The second most cited reason for investment in production plants was to add new capability, which would enable companies either to expand the range of products manufactured or to increase overall output. American firms cited the addition of new capability to their production plants as the prime driver for investment in plants.

With regard to spending on manufacturing equipment, foreign HPE companies said their chief reason (seven mentions) was to replace old equipment. U.S. companies also said that this was their first priority. The next most important reasons for machinery and equipment expenditures by foreign manufacturers were either a need to expand capacity or a need to comply with environmental and safety regulations. Both areas are commanding an equal level of attention from management with regard to investment priority and allocations.

Use of Taggants

To comply with multi-nation agreements or national laws, all three foreign firms have used taggants in their products. Two firms stated that taggants have affected their operations. One company said the taggant it used was expensive but noted that other manufacturers face the same costs. Another firm stated that the taggant is difficult to work with. These comments are consistent with the views of U.S. suppliers.

Exports as a Source of New Business

Two of the three non-U.S. firms stated that they had benefited from expanding their markets overseas. For one firm, the U.S. has been a growing market over the past several years. Many foreign suppliers need export markets to support their bottom lines because they do not have a robust home market for their products.

One foreign firm, who exports the vast majority of its product to other nations, said that its presence in the U.S. market was a positive development. This firm believes that it has promoted competition and lower costs in the U.S. HPE market.

Defense Conversion and Recycling of HPEs

The responding firms all participate in some form of product diversification. All produce commercial demolition explosives and two of the three firms make HPEs for the oil well drilling industry. These markets are similar to what some U.S. companies have chosen to pursue.

Two of the three foreign firms are not interested in the recycling of HPEs. The interested firm was evaluating the concept of recycled explosives at the time it submitted its survey. Two of the firms, in their discussion of the advantages and disadvantages of using recycled HPEs, mentioned some of the same issues as U.S. firms. They said recycled HPEs would have to meet military specifications in order to be used or would have to be used in less stringent civil applications.

The Future in General

Foreign participants in the HPE and HPEC assessment took different perspectives in describing the future. One firm called it "survival of the fittest" if competition on equal terms prevails. This firm went on to say that demand for ammunition, and therefore HPEs, will fall in the future.

On the technical front, another firm stated that future HPEs would become more insensitive. Insensitive explosives would increase the safety of munitions, reduce the vulnerability of storage areas and warehouses, and reduce operating and maintenance costs.

The third respondent stated that after a series of mergers and acquisitions, firms would begin to concentrate on core and differentiating competencies. This would create companies with areas of particular expertise for particular products.

Foreign HPE Capability vs. U.S. HPE Replenishment Needs

An important concept when evaluating the ability of foreign manufacturers to produce items for the U.S. market is replenishment. Department of Defense replenishment policy calls for restoring munitions stockpiles to pre-combat levels within three years of the close of a conflict. The replenishment of munitions would create a large spike in demand for HPEs. In fact, the amounts of HPEs needed (over twenty different compositions totaling over 100 million pounds) would far exceed yearly peacetime production needs.[46]

Foreign manufacturers do not have to maintain excess capacity to fulfill the replenishment mission. Foreign manufacturers have sized themselves to fill the orders of the peacetime market -- not the requirement that the U.S. might have during war or following a major conflict.

On an international site visit, BXA and NSWC Indian Head staff noted that one manufacturer's HMX operations used one reactor with no backup. With no redundancy in key manufacturing equipment, production could be disrupted for a substantial period. In addition, this facility was operating seven days a week, 24 hours a day to keep up with orders. It was apparent that this foreign firm would not be able to respond to a spike in demand.

In the mid-to late-1990s, the lower overhead of these foreign producers made them attractive to U.S. HPE buyers (frequently the PMs or PEOs), who were interested in finding the best price for their HPEs. However, there is risk to the U.S. HPE manufacturing base in relying on overseas producers for HPE production, particularly in times of conflict.

[46] To illustrate the difference between peacetime needs and replenishment needs, HSAAP, before its shutdown, was producing approximately two million pounds of HPEs a year.

Competitive Assessment

More consolidations and mergers appear likely for the HPEC industry. Five of the survey respondents stated that they were contemplating acquisitions. Several other firms predicted that they would create alliances with competitors to pursue contracts jointly.

The respondents are pursuing other strategies for the future as well. Three survey respondents said they would make major capital investments while two organizations said that they would invest in new technology to lower costs. Three firms plan to increase exports to offset lower sales in the United States. Two respondents are investing in R&D to keep competitive.

The survey asked the respondents how they saw the future of the HPE and HPEC industries. Although many companies are optimistic about their own competitiveness, most are pessimistic about the long-term prospects, describing it as "bleak" or "very poor." One company warned that "foreign competition will drive us out of business."

A few firms, however, saw the prospects for these industries rising due to the forecasts that defense spending will increase over the next five to 10 years. One organization stated that business would increase due to inventories of current munitions being depleted and needing replenishment. Another respondent stated that there would always be room for well-managed companies.

Individually, however, the firms assert that they will survive -- and in some cases prosper. Other BXA assessments have seen this phenomenon as well. Firms believe that "the other guy" will be the one to go out of business.

Overall Competitiveness

The majority of manufacturers felt that their overall competitiveness either would improve somewhat or would stay the same *(See **Table 18** below)*. The respondents attributed their optimism to a range of factors.

Several organizations said they were taking steps to be more competitive, such as investing in new facilities, equipment, or R&D. One respondent stated that its overall prospects would increase greatly because a new manufacturing facility would increase its capability and capacity. For the same reason, the company was equally optimistic about its future domestic competitiveness.

Survey participants who expect things to remain the same predicted stagnant defense sales coupled with strong competition in the market. Several firms stressed that any decline in demand for their products would be met with some competitors leaving the HPE and HPEC businesses.

Table 18: Company Reported Competitiveness						
Categories of Competitiveness	Improve Greatly	Improve Somewhat	Stay the Same	Decline Somewhat	Decline Greatly	Not Applicable
Overall Competitiveness	1	12	13	3	1	0
Domestic Competitiveness	1	13	11	5	0	0
Worldwide Competitiveness	2	10	7	2	1	8

Source: U.S. Department of Commerce, BXA Industry Survey

Three respondents stated that tougher times were ahead because of competition from foreign sources, the Department of Defense and Energy laboratories, and U.S. producers. One manufacturer projected that its business would decline greatly, largely because of foreign competition.

Domestic Competitiveness

Most respondents concentrated their answers in the *improve somewhat* and *stay the same* categories. Several respondents gave the same reasons as in the overall competitiveness section for their answers. Still other organizations expected that through consolidation and the loss of competitors, they would increase market share in their respective markets.

Firms stating that their domestic competitive prospects would *stay the same* or *decline somewhat* again anticipate flat or declining U.S. defense sales, competition from Department of Defense and Energy laboratories, and imports from other nations.

International Competitiveness

At the international level, most firms said market conditions will *improve somewhat* or *stay the same*. Interestingly, several of the organizations that projected that their competitiveness would improve were relatively new to international marketing. One company that expects business to "improve greatly" credits a merger with increasing its ability to market its products. Another firm said that it is focusing on the international market and indicated that this is key to its success.

Respondents that projected that their competitiveness would *stay the same* cited increased world competition as the main cause. Two respondents that predicted a decline felt that European defense manufacturer consolidation would close the European market to outsiders. At the same time, they asserted that foreign governments assist their manufacturers to a greater extent than the U.S. government.

Mergers and Acquisitions

In the 1990s, mergers and acquisitions in the defense industry were common. This activity has created several large defense powerhouses. Boeing, Lockheed Martin, Northrop/Grumman, and Raytheon either are the prime contractor or are involved in the production of many major weapon systems made today.

The majority of these firms stated that mergers and consolidations at the prime level had affected them negatively. HPE and HPEC companies affected by mergers and acquisitions reported they now have a smaller number of customers. One organization reported that the larger firms have begun to pull back work normally subcontracted out. Another firm stated that the large defense primes are very capable technically and have less need for outside contractors than in the past.

In addition, many modern business practices promote having fewer subcontractors and entering into strategic relationships with those subcontractors that are used. Thus, becoming a subcontractor is tougher once a prime already has chosen one for a particular product.

Several major changes in business organization occurred during the course of the BXA study. Mason & Hangar and General Dynamics formed the American Ordnance Limited Liability Consortium (LLC), which combines the operations of the Iowa Army Ammunition Plant and the Milan Army Ammunition Plant.

In addition, in 1998, Primex Technologies purchased CMS Inc. This acquisition gave Primex access to new testing facilities in addition to load, assemble, and pack operations. In early 2001, General Dynamics purchased Primex Technologies. General Dynamics is a producer of combat systems, many of them ground combat systems, with the M1A2 tank for the U.S. Army being a high profile example. The addition of Primex adds medium and large caliber ammunition, warhead manufacturing, and propellant manufacturing to its portfolio. Because of this purchase, General Dynamics is in a position to provide combat vehicles and ammunition needed by its combat vehicles.

In April 1999, Day and Zimmerman acquired The Mason Company (Mason and Hanger). The acquisition created an entity that operates multiple Army ammunition plants and other government-owned facilities. Day and Zimmerman runs the Kansas and Lone Star Army Ammunition Plants (AAPs), the Hawthorne Army Depot, and the Department of Energy's Pantex plant, which assembles and disassembles nuclear weapons. In addition, Day and Zimmerman, by acquiring Mason and Hanger, owns Mason's 50 percent stake in American Ordnance, which gives them access to the Iowa and Milan AAPs.

In May 2000, another important acquisition occurred. Alcoa, America's leading aluminum manufacturer, announced that it would acquire Cordant Technologies for $2.9 billion. Cordant Technologies consists of three companies: Howmet Castings, Huck Fasteners, and Thiokol Propulsion.

In April 2001, Alliant Techsystems purchased Thiokol Propulsion. Both companies have extensive solid rocket motor experience for both military and commercial space applications. In addition, Alliant Techsystems will be purchasing Thiokol's energetic materials experience and several munitions programs.

BXA Assessment Summary and Recommendations

The HPE and HPEC industries are small. The 33 organizations responding to BXA's survey had combined HPE and HPEC shipments of approximately $513 million[47] in 1998 and employed approximately 7,900 people in the United States. These organizations were located in 17 states, with the most numerous concentrations in California and Tennessee.

Overall Performance of the HPE and HPEC Industries

While U.S. manufacturers of HPECs were relatively successful from 1995 to 1999, the nation's largest supplier of HPE was in crisis, a situation that affected both the company's federal government and private customers. The U.S. government-owned Holston Army Ammunition Plant[48] (HSAAP), which dominates HPE production in the United States, lost many of its customers. The reason: rising product prices attributed to high overhead expenses and reduced demand for its HPE products.

Department of Defense (DoD) weapon systems program managers reacted to these higher prices by finding cheaper foreign alternatives. As a result, HSAAP's overhead problem grew bigger because rising costs were spread over a smaller customer base, which drove prices even higher.

In 1998, the U.S. Army solicited bids for a new supplier of HPEs. The Army selected Royal Ordnance[49] (a part of Great Britain's BAE Systems) as the new manager for its underutilized HSAAP facility.

Production was stopped except for a few items. The result of this "shutdown" and change of contractor was a 55 percent reduction in HPE shipments. During this time, it appears that the vast majority of the weapon system programs that left HSAAP bought their HPEs from overseas vendors located in Norway and Sweden.

Royal Ordnance, the first foreign contractor to manage HSAAP, immediately began reorganizing the government manufacturing facility's operating structure, lowering costs, and significantly reducing prices for HPEs. Royal Ordnance is currently trying to win lost customers back as contracts expire.

In contrast, private U.S. manufacturers of HPECs experienced an upward trend during the mid-to late-1990s. Shipments from these producers, as measured in dollars[50], rose 12 percent from 1995 to 1999.[51] However, all is not well for U.S. HPEC producers. As

[47] Two government-owned, contractor-operated facilities could not provide shipment data in the form requested.
[48] HSAAP is located in Kingsport, TN. HSAAP produces HMX and RDX, HPEs with many defense applications.
[49] Royal Ordnance is a British company, which manufactures explosive materials. BAE Systems, an aerospace conglomerate, owns Royal Ordnance.
[50] Dollars over time are not adjusted in this assessment.
[51] Increasing shipments in what appears to be a declining market may be due to a small increase in munitions procurement spending from 1995. The effects of spending increases and decreases often lag a year or more, according to the Director of the Munitions Industrial Base Task Force.

might be expected, the spending downturn at the Department of Defense over the last 15 years has reduced the HPEC sector's capital investment. It has lagged the rest of U.S. manufacturing for over 10 years, according to Census Bureau data.

Future Budget Trends – Procurement, Research and Development Slide

The Department of Defense munitions budget funds both the HPE and HPEC industries. The budgets for munitions procurement and for R&D have fallen substantially since the mid-1980s. According to DoD, from 1986 to 1998, procurements of munitions (the primary finished product for HPEs and HPECs) dropped 81 percent.[52] This steep budget decline caused firms to leave the HPEC business, resulting in consolidation of the remaining suppliers. Procurement expenditures for munitions by DoD are expected to stabilize at between $4.3 and $4.6 billion a year from 2002 to 2005. This level of spending should help stabilize the remaining firms in both the U.S. HPE and HPEC industries as long as the majority of contracts are awarded within the U.S. industrial base.

R&D expenditures are an investment in the future. However, since its 20-year high in 1989, DoD spending on munitions research, development, testing, and evaluation (RDT&E) has fallen nearly 45 percent. According to current projections, RDT&E spending on munitions will plunge another 50 percent to about $820 million by 2005.

What makes this issue even more serious is that munitions RDT&E is also falling as a percentage of DoD's overall RDT&E budget. Munitions RDT&E was between four and six percent of the overall DoD RDT&E budget from 1986 to 2000. After 2000, however, the munitions portion shrinks to about 2.4 percent of the overall defense RDT&E budget. This reduced investment in RDT&E may slow innovation and hinder the ability of the United States to field cutting-edge munitions technologies.

Reduced RDT&E spending will almost certainly degrade the ability of firms and government organizations to hire and retain scientific and technical staff. Drastic budget cuts will send a loud signal to the chemistry and physics communities that there are few opportunities in the field of high performance explosives. Scientists and engineers will simply vote with their feet—opting to "follow the money" to financially healthier areas of research.

Potentially serious employment issues with scientists, engineers, and production workers await the HPE and HPEC industries in the next decade. As the BXA survey results and anecdotal[53] evidence suggest, a generation of HPE and HPEC workers are expected to retire in the next 10 to 15 years. It is uncertain whether this approaching loss of workforce knowledge will be avoided.

If R&D initiatives and workforce skills erode, then there will be a reduced capability of the HPE and HPEC industries to deliver to DoD effective and innovative munitions in the

[52] Office of Munitions, Office of the Secretary of Defense.
[53] Anecdotal evidence is evidence based solely on in-person and telephonic interviews with industry officials, conducted by BXA.

future. DoD and industry officials must start planning now for replacing an aging workforce.

Production Capacity Ownership Breakdown

Production of HPEs and HPECs in the United States is divided between facilities owned (and in some cases operated) by the U.S. government and facilities operated by private industry. The government-owned facilities were constructed before and during World War II and have the capacity to make very large amounts of products. These plants have been used during times of prolonged conflict (World War II, the Korean War, and the Vietnam War), but often their capacities have been underutilized or unutilized during times of peace.

Most government-owned, contractor-operated (GOCO) plants currently run at low workloads compared to their total capacities, raising the GOCOs' expenses and increasing the cost of items produced. However, these federal production facilities are the only plants capable of replenishing the stocks of certain types of ammunition and ammunition components used by the armed forces. Department of Defense policy requires the replenishment of ammunition stocks within three years of a major conflict.

GOCOs compete at times against the smaller and sometimes more agile contractor-owned, contractor-operated facilities (COCOs). While providing similar products, frequently at a lower price, COCOs cannot manufacture items in the volume needed in time of war. These companies also lack the capacity to replenish the U.S. stockpiles of particular munitions to mandated levels within the required three years.

With greatly reduced defense spending, there are fewer orders for both GOCOs and COCOs to win. GOCOs, with their larger overhead, often find it difficult to compete against the prices offered by the smaller COCOs. COCOs often view military orders awarded to GOCOs not as contracts that are awarded because of best price but as an effort to keep GOCOs in business.

U.S. HPE Production Capability – Rebounds with HSAAP'S Overhaul

No other producer, in the United States and possibly the world, can manufacture the variety and the quantity of explosives that HSAAP can produce. Since taking over operation of the complex from the Holston Defense Corporation, the previous GOCO operator, Royal Ordnance has brought down the price of HPEs substantially. The new operator delivers bulk HPEs to the Army at a fixed price, and offers competitive contracts for HPEs to other DoD weapons systems programs.

To achieve this turnaround, Royal Ordnance has reduced overhead expenses, reconfigured the production plant, changed HSAAP's organizational structure, and leased out space on the facility site to commercial tenants. As a result, the economic viability of HSAAP is improving.

As with HSAAP, commercial U.S. manufacturers of HPEs have been hurt by cutbacks in government orders. These private companies are very small compared to HSAAP and they focus on manufacturing HPEs for specific applications: unique military products, oil exploration, and focused research and development programs. Shipments from these producers fell almost 21 percent from 1995 to 1999, with one producer accounting for most of the drop.

Shipment Trends – Mixed Performance, Uncertain Future

Shipments of high performance explosives decreased nearly 55 percent from $78.9 million to $35.6 million from 1995 to 1999, according to the BXA survey. The primary cause of the decrease was the cutback in production and subsequent temporary closure of HSAAP. The outlook for future HPE shipments is uncertain. Royal Ordnance is challenged with winning back lost customers who turned to foreign suppliers, principally in Norway and Sweden.

Unlike HPE production in the United States, which decreased substantially between 1995 and 1999, shipments of HPECs stayed level or increased slightly with sales climbing nearly 12 percent to $441 million as compared to $394 million in 1995.

Employment Concerns – Looming Problems for Industry

Skilled employee issues are among the most difficult challenges facing this sector. Work with HPEs is inherently dangerous, especially on the production side, where large amounts of energetic materials can be involved. The safety concerns alone call for an experienced, well-trained work force. In addition, the unique manufacturing talents of the process operator historically have influenced the quality of HPEs and HPECs.

The result of the early 1990s "peace-dividend" for many in the U.S. HPEC industry has been the lowest level of employment seen since 1963.[54] When these munition industries downsize, they frequently retain older workers, running the risk of losing talent when a generation retires. Anecdotal evidence collected through interviews with corporate executives and government officials who work in the munitions sector suggest that some "brain drain" of scientists, engineers, and production workers has already occurred in both the HPE and HPEC communities.

Survey respondents report that some of the most troublesome bottlenecks, which prevent manufacturers from achieving full production, are labor related. If all of the labor issues (labor availability, labor training, and expertise) reported by the respondents are combined, they may constitute these industries' most significant challenge -- and could require the greatest amount of time and money to solve.

[54] Historical employment data from the Bureau of the Census is used in this report from 1963 to 1998. The definition for Standard Industrial Classification (SIC) Code 3483 (Ammunition over 30mm) has remained consistent since 1963. However, the definition changed significantly in 1963; therefore, data before 1963 is not comparable.

Investment in Operations – Capital Spending Lags Manufacturing

Investment information collected by the Bureau of the Census and BXA shows a lack of new investment in the HPEC community. Census data indicate that private sector producers of HPECs are not investing in their operations on par with the rest of U.S. manufacturing.

Before recovery in 1997, HPEC industry capital expenditures[55] had fallen 84 percent from its peak in 1988. While the rest of U.S. manufacturing has achieved capital expenditure growth from approximately $5,500 to $7,500 per employee for the period of 1988 to 1996, the HPEC industry's capital expenditure growth was comparatively miniscule, fluctuating at approximately $1,000 to $2,000 per employee.

Research and Development – Long-Term Decline Affects Industry

All of the armed services have steadily cut spending on R&D for munitions (which includes HPEs and HPECs) in recent years. DoD funding for research, development, testing, and evaluation (RDT&E) for munitions is expected to continue on a downward slope. By 2005, DoD RDT&E spending is projected to be 70 percent below 1989's peak funding level of $2.8 billion.

The funding reductions break the historical support patterns for munitions R&D at DoD. Munitions RDT&E is falling as a percentage of DoD's overall RDT&E budget. Munitions RDT&E averaged four to six percent of the overall DoD RDT&E budget from 1986 to 2000. By 2005, however, the munitions portion is expected to sink to about 2.4 percent of the overall Defense RDT&E budget.

R&D spending by BXA-surveyed private companies and GOCOs engaged in manufacturing HPEs and HPECs fell 12.3 percent from 1995 to 1999. Outlays for HPE and HPEC R&D by federal agencies plummeted nearly twice as much – by 23 percent. The decline in R&D has damaging effects. It not only slows the development of new materials and munitions, but it also limits the ability of firms to hire and retain scientific staff to work on R&D projects.

While overall support for R&D is falling, some private HPE and HPEC companies continue to try to leverage their limited R&D budgets. Six firms within the HPE and HPEC industries have established relationships with seven universities to undertake joint R&D projects. The majority of these projects were sponsored exclusively with company funds. Most of the firms that have collaborated with universities plan to collaborate again if a worthwhile project materializes. At least one firm has funded research at multiple universities.

[55] For definition, please see the Census Bureau's *Ammunition (Except Small Arms)*, 1997 Economic Census Manufacturing Report (http://www.census.gov/prod/ec97/97m3329a.pdf), page A-5.

Import and Export Issues – Foreign Regulatory Hurdles Thwart U.S. Firms

HPE and HPEC producers have experienced various difficulties exporting their products. The causes for exporting delays come from both the purchasing nations and the U.S. government. Some countries require approved export licenses for proposed sales and mandate that shipments must be delivered by the purchaser's ships rather than by carriers chosen by the U.S. producer. As a result, shipping delays can occur, which can produce cost increases and reduce cash flow for U.S. manufacturers. Other survey respondents reported that their firms have been forced to comply with defense trade offset agreements required by foreign governments, a market-distorting trade barrier that can significantly erode profits of U.S. producers and undermine their economic viability.

Munitions trade with Canada is another area of concern for the U.S. industrial base. Canada has special access to the United States' defense market through bilateral agreements. In many cases, Canadian companies are treated like U.S. firms. Canada is even considered a part of the U.S. technological and industrial base by DoD. American HPEC companies, however, do not have the same access because of restrictive procurements by the Canadian government. In addition, U.S. companies are often penalized by having to enter into offset agreements on their sales to Canada.

HPE and HPEC producers face delays in receiving export licenses, which can prompt customers to consider foreign sources of supply. Survey respondents urged that the United States government expedite export licenses, and they requested that the Departments of State and Commerce practice more uniformity in their licensing procedures.

The Competition – U.S. Industry Compared to Selected Foreign Suppliers

Many nations are capable of producing HPEs and HPECs. European manufacturers (Sweden and Norway being the most prolific suppliers) of HPEs are the strongest competitors to the United States' primary source of HPEs -- HSAAP. Several European producers surveyed by BXA have not reduced production of HPEs as much as HSAAP – and in one case, have increased production. These firms have been able to sell more of their products in the U.S. due to the rise in HSAAP's HPE prices starting in the mid-1990s and its temporary closure in 1998. HSAAP's shipments declined approximately 55 percent from 1995 to 1999 because of these two factors.
Most European manufacturers have small home markets for their products and are looking to exports as a major source of revenue. One of their main target markets is the United States. Future market penetration by foreign manufacturers of HPEs is expected to be deterred by the competitive prices now offered by HSAAP.

U.S. Government Procurement – Fragmented Operations, Policies

Factors besides competition affect the HPE and HPEC sectors. One of the most important is the federal government. The U.S. government is the customer, partner, competitor, and regulator in these industries. Firms have to comply with follow

regulations developed by the Departments of Defense, State, Commerce, and Transportation; the Environmental Protection Agency; and others.

Environmental Regulations – Loose Rules Overseas May Skew Competition

The production and use of HPEs and HPECs creates hazardous wastes. In many cases, the HPEs themselves are hazardous materials, capable of contaminating the environment. Environmental regulations over the past 30 years have become stricter for U.S. companies and this trend will most likely continue. Compliance adds to the cost of production, making it more difficult for firms to compete internationally in the HPE and HPEC markets with nations that may not have the same level of regulation.

Operating costs for some U.S. HPE and HPEC operations may escalate in the future as companies have to bear the cost of cleaning up contamination at their sites. The energetic materials sector, including HPE and HPEC manufacturers and particularly the government-owned and/or operated facilities, does not have a strong record of environmental stewardship. This potential for incurring higher cost is affirmed in the Energetic Materials Environmental Study published by DoD's Strategic Environmental Research and Development Office. The study found that government facilities were slower to address environmental issues than the private sector.

A key policy question that DoD top management and munitions procurement officials must consider is whether it is appropriate for the department to buy HPEs from foreign suppliers that may have environmentally "dirtier" manufacturing operations and as a result of those operations gain a cost advantage over U.S. firms.

Future of the Industries – Prospects Mirror Curve of Declining Demand

Respondents were neutral to optimistic about their own future, but pessimistic about the future of the overall industries. Many HPE and HPEC producers stated that their individual prospects in the next five years would remain the same or improve somewhat. When the respondents spoke of the future of their industries as a whole, however, they used descriptions such as "bleak" or "very poor" because of the declining demand for their products and reduced R&D spending.

Several survey respondents predict that more consolidation will occur within the HPEC industry in the future. To some extent, this activity is healthy to the extent that it brings stability to DoD's supplier base. Three recent mergers, in fact, are viewed by some industry executives as having increased the capability of the suppliers to provide more complete product solutions to the U.S. military.

Recommendations

Issue 1. – Research and Development

Research and development spending has been falling in the HPE and HPEC industries, according to DoD and BXA data. Since 1989, RDT&E spending has fallen 45 percent. According to current projections, DoD support for munitions R&D will plunge another 50 percent to about $820 million by 2005. This decline represents a historical shift in support for munitions R&D. The munitions RDT&E budget is falling from approximately four to six percent of the total DoD RDT&E budget (1986-2000) to about 2.4 percent by 2005.

Anecdotal and survey evidence collected by BXA suggests that the HPE and HPEC industries could suffer a major loss of engineering and scientific talent in the next 10 to 15 years due to declining defense funding and a graying workforce. BXA recommends that DoD take the following steps to reverse this trend:

Recommendation A

DoD should restore munitions funding to its 14-year average of between four to six percent of overall RDT&E spending. This level of spending would come much closer to providing the resources required for maintaining a culture of innovation within federal and private research facilities. Higher funding levels are essential if DoD is to retain existing professional staff and is to develop new technical talent.

Recommendation B

DoD should establish a $10 million-a-year, competitive research grant program that would be open to U.S. industry and U.S. government research organizations. Both organizations can enlist U.S. research universities in their research program, when it is deemed necessary. This program should be designed to bolster basic and early-applied research capabilities with the goal of developing new and improved energetic materials to meet national security needs.

The scope of the R&D program should be determined by a multi-service panel, which includes at least two representatives of the U.S. HPE industry and two members affiliated with top research universities. Research grants can be for one, two, or three years, depending on need. An expert peer-review panel should award these grants on a competitive basis. This funding should be used to supplement (not replace) funds normally spent by industry and government on munitions related R&D. The R&D grant program should target specific engineering and scientific challenges identified by the multi-service panel at the outset of the program.

Recommendation C

There should be an expansion of R&D efforts funded under DoD's ManTech Program to support the munitions community's pursuit of process improvements that promise

product performance gains, safe process and materials handling, methods for reducing manufacturing costs, and ways to lessen manufacturing-related environmental impacts.

Issue 2. – Purchasing of HPEs from Non-U.S. Sources

In the 1990s, DoD procurement officials increasingly purchased their HPEs from cheaper foreign sources instead of U.S. suppliers, principally HSAAP. The procurement decisions reduced production volumes at HSAAP -- and drove HSAAP's overhead costs and product prices for HPEs even higher. Consequently, even more defense procurements were shifted away from HSAAP.

While DoD procurement officers are supposed to consider "best value" factors in making their purchasing decisions, their deliberations appear weighted in favor of product pricing. Potentially less restrictive environmental rules in some countries may give foreign suppliers a pricing edge in procurements. U.S. suppliers may also be disadvantaged by temporary swings in financial markets, which elevates the dollar relative to other currencies to unusually high levels.

Recommendation A

Procurement officers within DoD should comply with requirements that they consider economic, trade, industrial base, and environmental factors affecting U.S. suppliers of HPEs in making price-based decisions in awarding supply contracts to foreign vendors.

Recommendation B

DoD should not allow supplier acceptance of trade offset obligations to be a deciding factor in the scoring and selection of HPE suppliers.

Recommendation C

DoD should investigate whether a "Buy America" provision is needed for HPEs to ensure a responsive U.S. manufacturing base. The department should consider establishing a minimum tonnage threshold for annual purchases for U.S. HPE suppliers. A technical advisory panel should determine the level of domestic production that is adequate to maintain the economic and technical health of the U.S. HPE manufacturing sector—and to guarantee that national security requirements can be met.

The "Buy America" provision would only activate when annual purchases dropped below this threshold and would be deactivated when DoD purchases exceeded the threshold by 5 percent. DoD would be free to buy HPEs from foreign suppliers except when domestic manufacturers' volumes drop below the threshold level. In no instance should DoD be prevented from buying from foreign suppliers those explosive materials and compounds that are not available from domestic manufacturers.

Issue 3. – Recycling of HPEs (Opportunity and Challenges)

One third of the respondents to the BXA survey expressed interest in the concept of recycling HPEs. The recycling of HPEs is consistent with the intentions of the September 1998 Executive Order 13101, which mandates greater use of recycled material in all government operations, including munitions.

Currently, several firms are developing processes to remove HPEs from warheads and rocket motors. Many technical issues, however, need to be resolved before recycled HPEs can be used in military applications. In addition, recycled HPEs could adversely affect the economics of producing virgin HPE material at HSAAP by reducing production volume to less than acceptable levels.

Recommendation

The Department of Defense should form an industry/government panel consisting of engineering and manufacturing experts to investigate the utility of recycled HPEs in defense applications. This panel should examine and report on the technical challenges, economic opportunities and impacts, environmental liabilities, and related safety issues associated with recycling HPEs. This panel should deliver a final report to DoD within 18 months.

Issue – Role of U.S. Government-Owned Manufacturing Capacity

The U.S. Army owns significant manufacturing capacity within the HPE and HPEC sectors. A U.S. law, called The Arsenal Act[56], requires that the Army manufacture its supplies (including HPEs and HPECs) in government-owned factories -- presuming the plants can manufacture the item on an economical basis. In 1998, the U.S. Army published what appears to be a contradictory instruction, the Industrial Base Policy Letter 98-1. It states that the Army should rely on the private sector for its ammunition needs and transfer government manufacturing assets to the private sector "to the maximum extent feasible." The goals of the Army's 1998 policy letter do not appear to be fully compatible with federal law.

Recommendation

The U.S. Army should either amend or eliminate its Industrial Base Policy Letter 98-1 to produce consistency with the Arsenal Act; or it should seek legislative action by the U.S. Congress to amend or eliminate the Arsenal Act.

[56] Title 10 U.S. Code 4532

Appendix A

Survey Document

OMB Control 0694-0109
Expires 06-30-01

U.S. Department of Commerce
Bureau of Export Administration

NATIONAL SECURITY ASSESSMENT OF THE U.S. HIGH PERFORMANCE EXPLOSIVES AND COMPONENTS INDUSTRY

PURPOSE OF THIS ASSESSMENT

The U.S. Department of Commerce/Bureau of Export Administration and the Department of the Navy/ Naval Sea Systems Command are working together on a national security assessment of the U.S. high performance explosives industry. The goal of this joint assessment is to analyze the long-term health and competitiveness of this industry and to develop recommendations to ensure the continued ability of the industry to support defense missions and programs. Your timely and complete response will assist the Department of Commerce in its efforts to perform a comprehensive analysis of this critical industrial sector for senior policy officials. A copy will also be sent to you, as a market research resource and to help you to gauge your firm=s strengths and weaknesses in comparison to the entire industry.

YOUR RESPONSE IS REQUIRED BY LAW

This assessment is conducted pursuant to the Defense Production Act of 1950, as amended (DPA) (50 U.S.C.A. app. section 2061-2171 (1991 & Supp. 1997)) and as delegated to the Secretary of Commerce in sections 401(4) of Executive Order 12656 (3 C.F.R. 585 (1988 comp. 1989)). Your response to this questionnaire is required under section 705 of the DPA (50 U.S.C.A. app. section 2155). Any information submitted in response to this questionnaire will be deemed **CONFIDENTIAL** and treated in accordance with section 705 of the DPA. Not withstanding any other provision of law, no person is required to respond to nor shall a person be subject to a penalty for failure to comply with a collection of information subject to the requirements of the Paperwork Reduction Act unless that collection of information displays a currently valid OMB Control Number.

Burden Estimate and Request for Comment: Public reporting burden for this collection of information is estimated to average 6 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to BXA Reports Clearance Officer, Room 4513, Bureau of Export Administration, U.S. Department of Commerce, Washington, DC 20230, and/or to the Office of Management and Budget, Paperwork Reduction Project (OMB Control 0694-0109), Washington, DC 20503.

EXEMPTION

If your firm has not produced high performance explosives in the United States since January 1, 1995, or sold your high performance explosives operations before January 1, 1995, you are not required to complete this form. Please use the definitions page and the product categories listed on page two to determine your ability/inability to produce high performance explosives. If you qualify for an exemption, please provide the information requested below and return this page.

Name of Company	**Address (City, State)**
Signature of Authorized Official	**Date**
Name of Official- Please Print	**Phone**

If your firm exited the high performance explosives industry before January 1, 1995, please indicate why your firm exited the business. If your firm sold its high performance explosives business since January 1, 1995 please indicate to whom you sold the business and your reasons for selling to that particular firm.

GENERAL INSTRUCTIONS

1. Please complete this questionnaire in its entirety as it applies to your company's high performance explosive operations. The questionnaire has 6 parts as follows:

SECTION 1	PART I	FIRM IDENTIFICATION
	PART II	PRODUCTION CAPABILITIES
	PART III	SHIPMENTS, IMPORTS, EXPORTS AND EMPLOYMENT
	PART IV	INVESTMENT AND FINANCIAL
	PART V	RESEARCH AND DEVELOPMENT AND TECHNOLOGY
	PART VI	COMPETITIVENESS

SECTION 2 SUBCONTRACTOR IDENTIFICATION

2. It is not our desire to impose an unreasonable burden on any respondent. IF INFORMATION IS NOT READILY AVAILABLE FROM YOUR RECORDS IN EXACTLY THE FORM REQUESTED, FURNISH ESTIMATES AND DESIGNATE BY THE LETTER "E".

3. Report calendar year data, unless otherwise specified in a particular question. Please make photocopies of forms if additional copies are needed.

4. Questions related to the questionnaire should be directed to Brian Nilsson at 202-482-2376 or E-mail, *bnilsson@bxa.doc.gov*, or Chris Weller 202-482-8236 or E-mail *cweller@bxa.doc.gov*, or Steve Baker 202 482-2017 or *sbaker@bxa.doc.gov* or all three at 202-482-5650 (FAX), at the U.S. Department of Commerce.

5. Before returning your completed questionnaire, be sure to sign the certification on the last page and identify the person and phone number to be contacted (if necessary) at your firm. Return questionnaire within 30 days to:

Mr. Brad Botwin
Director, Strategic Analysis Division
Rm 3876, BXA
Ref: HPEM
U.S. Department of Commerce
Washington, DC 20230

DEFINITIONS

BOOSTER EXPLOSIVE - A material with a sensitivity between that of a primary and a main charge explosive. It is used to transmit and augment the detonation reaction (initiated by the primary explosive) with sufficient energy to initiate reliably a stable detonation reaction in the main charge explosive.

DEFENSE SHIPMENTS - Direct and indirect military shipments, including: (**1**) weapon systems, support equipment, and all other defense related end-use items, identified by purchase orders bearing a DO or DX rating and/or a contract number from the Departments of Defense and/or Energy, Nuclear Regulatory Commission, Central Intelligence Agency, Federal Aviation Administration, National Security Agency or the National Aeronautics and Space Administration; (**2**) the orders of your customers which you can identify as producing products for defense purposes; and (**3**) items tested and certified to military specifications.

ESTABLISHMENT - All facilities in which high performance explosives are produced. Includes auxiliary facilities operated in conjunction with (whether or not physically separate from) such production facilities. Does not include facilities solely involved in distribution.

HIGH PERFORMANCE EXPLOSIVE - A substance or mixture of substances capable by chemical reaction of producing gas at high temperature and pressure so as to cause damage to the surroundings. For the purpose of this survey, a high performance explosive is one that reacts readily on demand and furthermore has applications as a primary, booster or main charge explosive in a system of military interest.

FIRM - An individual proprietorship, partnership, joint venture, association, corporation (including any subsidiary corporation in which more than 50 percent of the outstanding voting stock is owned), business trust, cooperative, trustees in bankruptcy, or receivers under decree of any court, owning or controlling one or more establishments as defined above.

FULL PRODUCTION CAPACITY - The maximum level of production that an establishment could reasonably expect to attain under normal operating conditions. In estimating full production, consider the following: (**1**) Assume only the machinery and equipment in place and ready to operate will be utilized. Do not consider facilities or equipment that would require extensive reconditioning before they can be made operational. (**2**) Assume normal downtime, maintenance, repair and cleanup. (**3**) Assume number of shifts and hours of plant operations under normal conditions are not higher than that attained by your plant any time during the past five years. (**4**) Assume overtime pay, availability of labor, materials, utilities, etc., are not limiting factors. (**5**) Assume a product mix that was typical or representative of your production during the last quarter. If your plant is subject to considerable short-run variation assume the product mix of the current period. (**6**) Do not assume increased use of productive facilities outside the plant for services (such as contracting out subassembly work) in excess of the proportion that would be normal during the last quarter.

HARMONIZED TARIFF SCHEDULE - The Harmonized Tariff Schedule (HTS) is a numeric system of classifying imports and exports that is used by many nations including the U.S. This mandatory classification system is designed to enable importers, customs brokers, customs officers and other interested persons to determine (**1**) the classification of and rates of duty applicable to imported articles and (**2**) the requirements for reporting statistical data with respect to such imports or exports. The publishing and updating of the HTS is the responsibility of the United States International Trade Commission (ITC) while the responsibility for administering the tariff and for processing import duties falls on the United States Customs Service.

MAIN CHARGE EXPLOSIVE - A material that is less sensitive than a booster explosive and is generally used as the final charge in any explosive application.

OFFSET AGREEMENTS - Offsets are defined as industrial or commercial compensation practices required by foreign Governments as a condition of purchase of military imports. Common types of offsets include licensed production of the defense item (or parts thereof) in the purchasing country, technology transfer, foreign investment, and counter trade.

PRIMARY EXPLOSIVE - Sensitive material used to initiate chemical reaction in booster explosives. Primary explosives are sensitive to heat, impact and shock.

RESEARCH AND DEVELOPMENT - includes basic and applied research and product development in the sciences and in engineering, and design and development of prototype products and processes. For the purposes of this

questionnaire, research and development includes activities carried on by persons trained, either formally or by experience, in the physical sciences including related engineering, if the purpose of such activity is to do one or more of the following things: (**1**) Pursue a planned search for new knowledge, whether or not the search has reference to specific application. (**2**) Apply existing knowledge to problems involved in the creation of a new product or process, including work required to evaluate possible uses. (**3**) Apply existing knowledge to problems involved in the improvement of a present product or process.

SHIPMENTS - Domestically manufactured products shipped by your firm during the reporting period. Such shipments should includes inter-plant transfers, but should exclude shipments of products produced by other manufacturers for resale under your brand name. Do not adjust for returned shipments. (See definition of DEFENSE SHIPMENTS above.)

STANDARD INDUSTRIAL CLASSIFICATION (SIC) NUMBERS - SICs are used by the Bureau of the Census for the classification of establishments by type of activity in which they are engaged; for purposes of facilitating the collection, tabulation, presentation, and analysis of data relating to establishments; and for promoting uniformity and comparability in the presentation of statistical data collected by various agencies of the United States Government, State agencies, trade associations, and private research organizations. Virtually all forms of manufacturing fall into a SIC number.

UNITED STATES - Includes the fifty States, Puerto Rico, the District of Columbia, the Virgin Islands, and the Trust Territories of the Pacific Islands.

SECTION 1

PART I: FIRM IDENTIFICATION

1. COMPANY NAME AND ADDRESS: Please provide the name and address of your firm or corporate division.

_____
Company Name

_____
Street Address

_____
City, State, Zip Code

2. OWNERSHIP: If your firm is wholly or partly owned by another firm, indicate the name and address of the parent firm and extent of ownership.

_____
Company Name

_____
Street Address

_____
City, State, Zip Code (Country)

Extent of Ownership:_____(percent)

3. ESTABLISHMENTS: Please identify the location of each of your U.S. and foreign high performance explosives operations establishments. Indicate the products researched and/or manufactured at each location. (See list on page two)

ESTABLISHMENT LOCALITY	STATE/ COUNTRY	ZIP	PRODUCTS RESEARCHED AND/OR MANUFACTURED

In addition, please include any literature (annual report or product information) that would give us an overview of your company, its history, etc.

Please include any additional comments on Part I at the end of this document

PART II: CAPABILITIES

1. Please indicate (T) which component(s) and/or finished explosive(s) you Research, Manufacture and/or Sell. Item lists under the categories are not all inclusive. Please select the closest type or category. If a particular subcategory is not listed, check the main box, or if necessary, specify in Aother@ category. Please list any applicable national stock numbers (NSNs) on the line next to the explosive or component. If you need additional space please list additional NSNs and their description on an additional page.

EXPLOSIVES	R	M	S	APPLICABLE NATIONAL STOCK NUMBERS
Explosive Ingredients				
Explosive Ingredients	☐	☐	☐	_____
Primary Explosives	☐	☐	☐	_____
Booster Explosives	☐	☐	☐	_____
Main Charge Explosives				_____
Melt Cast	☐	☐	☐	
Pressed	☐	☐	☐	
Cast Cured	☐	☐	☐	
Other	☐	☐	☐	
Other	☐	☐	☐	_____
Specify: _____				

COMPONENTS	R	M	S	
Actuators	☐	☐	☐	_____
Arming Devices	☐	☐	☐	_____
Bombs				_____
Melt Cast	☐	☐	☐	
PBX Cast Cured	☐	☐	☐	
Bomblets				_____
Melt Cast	☐	☐	☐	
PBX Cast Cured	☐	☐	☐	
PBX Pressed	☐	☐	☐	
Boosters				_____
Pressed	☐	☐	☐	
Cast	☐	☐	☐	
Blasting Caps	☐	☐	☐	_____

COMPONENTS

	R	M	S	
Cartridges	☐	☐	☐	
Destructor Charges	☐	☐	☐	
Detonating Cord	☐	☐	☐	
Demolition Charges	☐	☐	☐	
Detonators	☐	☐	☐	
Hand Grenades	☐	☐	☐	
Initiators	☐	☐	☐	
Leads	☐	☐	☐	
Mines				
Melt Cast	☐	☐	☐	
PBX Cast Cured	☐	☐	☐	
Mine Neutralization Charges				
Melt Cast	☐	☐	☐	
PBX Cast Cured	☐	☐	☐	
Projectiles				
Melt Cast	☐	☐	☐	
PBX Cast Cured	☐	☐	☐	
PBX Pressed	☐	☐	☐	
Other	☐	☐	☐	
Rocket Warheads				
Melt Cast	☐	☐	☐	
Cast Cured	☐	☐	☐	
PBX Pressed	☐	☐	☐	
Other	☐	☐	☐	
Shaped Charges				
PBX Pressed	☐	☐	☐	
Extruded	☐	☐	☐	
Underwater Sound Signals	☐	☐	☐	
Torpedo Warheads				
Melt Cast	☐	☐	☐	
Cast Cured	☐	☐	☐	
Guided Missile Warheads				
Melt Cast	☐	☐	☐	
PBX - Pressed	☐	☐	☐	
PBX - Cast Cured		☐	☐	☐
Other	☐	☐	☐	

2. CEASED PRODUCTION: Identify any U.S. high performance explosives facilities which you have ceased production at since January 1995 or you expect to discontinue within the next two years. Please indicate the reason production was or will be curtailed (use letter codes provided below). Also please use the number codes to indicate whether the plant=s production can be revived in the future or if the plant=s capability is permanently lost.

REASONS

A. Loss of market share to imports
B. Loss of market share to domestic competition
C. Declining demand
D. Left voluntarily (low profitability)
E. Firm restructuring
F. Sold facility to another firm
G. Loss of qualified personnel
H. Inability to comply with environmental regulations (technical barriers, knowledge)
I. Inability to comply with environmental regulations due to cost (financial barriers)
J. Inability to comply with safety regulations (technical barriers, knowledge)
K. Inability to comply with safety regulations due to cost (financial barriers)
L. Other (Specify: _____)

STATUS OF PLANT OR PRODUCTION

1. Plant or production can be revived within _____ years
2. Plant or production can not be revived

YEAR	LOCATION (CITY/STATE)	PRODUCTION LINE OR WHOLE FACILITY (Circle One)	PERCENTAGE OF CAPACITY	REASON(S) (USE LETTER CODES)	STATUS OF PLANT OR PRODUCTION
		Pro or Fac	%		
		Pro or Fac	%		
		Pro or Fac	%		
		Pro or Fac	%		
		Pro or Fac	%		
		Pro or Fac	%		
		Pro or Fac	%		

Note: Please indicate in the third column if a product line or a whole facility was terminated/shut down

A. Does your firm maintain any of the equipment at idle facilities or lines? (i.e. lubricate, and periodically run dormant equipment)

☐ Yes ☐ No

B. What is you firm=s estimated annual cost for maintaining these facilities or lines?

_____

_____

Please include any additional comments on Part II at the end of this document.

PART III: SHIPMENTS, IMPORTS, EXPORTS AND EMPLOYMENT

1. SHIPMENTS IN UNITS: Please report the number of high performance explosives sold by your firm for the years below. Identify the product(s) (use categories from page two) and report your response in thousands of units where possible. Please provide estimates for 1997 and 1998. Please copy this page if you need additional spaces.

(THOUSANDS OF UNITS)

PRODUCTS: Write In:	Define Units	1995	1996	1997	1998E	1999E
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						

2. SHIPMENTS IN DOLLARS: Please report the amount of High Performance Explosives (HPE) sales by your firm for the years below. Use the product categories you listed above and report your response in thousands of dollars (for example, $25,000 = 25). Please copy this page if you need additional spaces.

(THOUSANDS OF DOLLARS)

PRODUCTS: Write In:	1995	1996	1997	1998E	1999E
1.					
2.					
3.					
4.					
5.					
6.					
Total					
% of HPE shipments to defense customers					
% of shipments that are/were exports					

3. HARMONIZED TARIFF SCHEDULE: For your exported items please list the corresponding Harmonized Tariff Schedule (HTS) numbers if known. (See definition for HTS at front)

_____

_____

_____

_____

_____

4. BARRIERS TO EXPORTS: Please comment on any trade barriers (e.g., tariffs, offset agreements, export control constraints, market access limits, foreign government subsidies or incentives, etc.) that you have encountered. Specify the country or countries, and the nature of the barriers.

Country_____

Nature of barrier_____

_____

_____

Country_____

Nature of barrier_____

_____

_____

Country_____

Nature of barrier_____

_____

_____

(Attach additional sheets if necessary)

5. IMPORTS OF KEY MANUFACTURING EQUIPMENT: Please complete the following table addressing what types of (key) foreign manufacturing equipment you use in your high performance explosive operations and the reason for using foreign sources. Use the following coded reasons to complete the table.

A. No known domestic source
B. Lack of availability from domestic source
C. Domestic source inadequate
D. Supplement to domestic source
E. Offset agreement (See Definitions)
F. Lower cost
G. Quicker delivery
H. Better quality/reliability
I. Other - specify:

_____

Equipment (Specify)	Foreign Producer Firm(s)	Country of Origin	Reason Foreign Sourced (use codes)

A. If you answered A, B or C to the question above, please identify actions you would take if your foreign source (s) were interrupted and what impact these interruptions would have on your customers.

_____

_____

_____

_____

6. IMPORTS OF KEY PARTS, RAW MATERIALS AND INGREDIENTS: Please complete the following table addressing what types of (key) foreign parts, raw materials and ingredients you use in your high performance explosives operations and the reason for using foreign sources. Use the following coded reasons to complete the table.

A. No known domestic source
B. Lack of availability from domestic source
C. Domestic source inadequate
D. Supplement to domestic source
E. Offset agreement (See Definitions)
F. Lower cost
G. Quicker delivery
H. Better quality/reliability
I. Other - specify:

_____

Parts and Raw Materials (Specify)	Foreign Producer Firm(s)	Country of Origin	Reason Foreign Sourced (use codes)

A. If you answered A, B or C to the question above, please identify actions you would take if your foreign source (s) were interrupted and what impact these interruptions would have on your customers.

_____

_____

_____

_____

7. **FUTURE DEPENDENCY:** Does your firm expect to become dependent or more dependent on imports of equipment, parts, raw materials and ingredients in the next two years? If so, please list the item(s), the company name of the supplier and the country of origin.

Item________________________________ Company____________________________

Country of origin__________________________

Item________________________________ Company____________________________

Country of origin__________________________

Item________________________________ Company____________________________

Country of origin__________________________

Item________________________________ Company____________________________

Country of origin__________________________

Item________________________________ Company____________________________

Country of origin__________________________

Item________________________________ Company____________________________

Country of origin__________________________

(Attach additional sheets if necessary)

8. BOTTLENECKS: Identify the top three bottlenecks your firm would encounter as you ramp-up to full capacity (*see definitions*) for high performance explosives production. Please select from the list shown below to identify the bottlenecks, as well as the cost to correct in $000s and the time to expressed in weeks to correct.

A. Raw Materials Handling
B. Other Materials Availability
C. Raw Materials Availability
D. Component Testing & Inspection
E. Production Scheduling
F. Assembly & Testing
G. Engineering (Design and Production)
H. Packaging & Delivery
I. Labor Availability
J. Labor Costs (Training)
K Availability of Expertise
L. Other _____

RANK BOTTLENECKS	BOTTLENECK (Use Codes)	COST TO CORRECT ($000)	WEEKS TO CORRECT
Bottleneck No. 1			
Bottleneck No. 2			
Bottleneck No. 3			

9. JOINT VENTURES: Has your firm entered into any joint ventures with foreign entities?

☐ Yes ☐ No

If yes, please indicate and explain if these ventures have increased or decreased your competitiveness.

_____

_____

_____

_____

10. SHORTAGES: If you have experienced any shortages or supply interruptions of production hardware, raw materials, supplies or ingredients in the last 5 years that caused or continue to cause an adverse affect on your high performance explosives manufacturing operations, please briefly characterize the nature of the problem and the action taken to correct or reduce the problem, including seeking assistance from any local, state or federal government sources.

Problem_____

_____

Actions taken _____

_____

_____

_____

Problem_____

_____

Actions taken _____

_____

_____

_____

Problem_____

_____

_____

Actions taken _____

_____

_____

_____

(Attach additional sheets if necessary)

12. DEFENSE CONVERSION: Please discuss your firms ability to diversify your high performance explosive defense production operations to commercial operation. Describe any successes or difficulties resulting from diversification. Please indicate if your operation has not attempted diversification and the reasons why.

13. RECYCLING OF HIGH PERFORMANCE EXPLOSIVES: What are your views on recycling of high performance explosives? What would be the advantages and disadvantages of producing recycled high performance explosives?

A. Is your firm interested in recycling high performance explosives?

☐ Yes ☐ No

B. Would a recycling initiative hurt your business base?

☐ Yes ☐ No

14. EMPLOYMENT BY OCCUPATION: Enter the number of employees (end of year) for your high performance explosive operating facility, as requested below. (Safety workers are defined as employees dedicated to fulfilling OSHA and other safety regulations)

OCCUPATION	1995	1996	1997	1998 E	1999 E
Marketing/Sales					
Technical Services					
Technicians					
Scientists and Engineers					
Production Workers					
Safety Workers					
Environmental Compliance					
Administrative					
All Others (define)					
Totals:					

Please define AAll Others@ from above:_____

15. EMPLOYMENT BY YEARS OF EXPERIENCE: Please check the box for the *average* number of years of experience (currently) for your high performance explosive operating facility, as requested below.

EXPERIENCE	0-10 Years	10-20 Years	20-30 Years	30+ Years
Marketing/Sales				
Technical Services				
Technicians				
Scientists and Engineers				
Production Workers				
Safety Workers				
Environmental Compliance				
Administrative				
All others				
Totals:				

A. Has the experience level (years experience) of your employees increased or decreased in the past five years?

☐ Increased ☐ Decreased

B. Has the average age of your work force increased or decreased in the past five years?

☐ Increased ☐ Decreased

16. LABOR CONCERNS: If in the **last five years** you experienced any labor problems, such as shortages of certain skills, excessive turnover, a retiring workforce, liability claims, etc., that adversely affect(ed) your high performance explosive operations, please describe them below:

_____

_____

_____

_____

_____

17. PROJECTED LABOR CONCERNS: If in the **next five years** you foresee experiencing any labor problems, such as shortages of certain skills, excessive turnover, a retiring work force, etc., that could adversely affect your high performance explosives operations, please describe them below:

_____

_____

_____

_____

_____

_____

18. ADDRESSING FUTURE LABOR NEEDS: What steps is your firm taking to address any labor shortages that have or may occur? Is your firm, (1) hiring and training new people to replace workers that leave, (2) moving people into high performance explosives from other operations or (3) are you not replacing works as they leave? Explain.

19. TRAINING: On average, how much money does your firm spend per employee (engineering and production) on training in your high performance explosives operations? Has that number gone up or down in the last five years?

Please include any additional comments on Part III at the end of this document.

PART IV: INVESTMENT & FINANCIAL

1. INVESTMENT: Enter expenditures for new plant, machinery and equipment, and used or rebuilt machinery and equipment (in $000) from 1995 to 1997, and projected amounts for 1998 and 1999 for your high performance explosives operations. Please indicate the reason(s) for the investment (use the letter codes provided).

A. Replace old equipment.
B. Improve productivity.
C. Expand capacity.
D. Add new capability.
E. Upgrade technology.
F. Meet specific customer's requirements.
G. Comply with environmental or safety requirements.
H. Other_____

	INVESTMENT IN OPERATIONS			
	Plant	Reason(s) (use codes)	Machinery and Equipment	Reason(s) (use codes)
1995				
1996				
1997				
1998E				
1999E				

What percentage of your firm's total investment applies to your high performance explosives operations?

_____%

2. INCOME STATEMENT: Enter the financial information for your entire firm (in $000s) as specified below for the years 1995-1997; use projections for 1998-1999.

(in thousands of dollars)

	1995	1996	1997	1998 E	1999 E
Sales					
Net Income:					

3. INCOME STATEMENT FOR HIGH PERFORMANCE EXPLOSIVES OPERATION(S): Enter the financial information for your high performance explosive operation only (in $000s) as specified below for the years 1995-1997; use projections for 1998-1999. Please estimate if this information is not collected separately.

(in thousands of dollars)

	1995	1996	1997	1998 E	1999 E
Sales					
Net Income:					

4. BALANCE SHEET: Please provide the balance sheet information for your entire firm (in $000s) as specified below for your latest accounting period. Please note that total assets should equal total liabilities.

CURRENT ASSETS	$	CURRENT LIABILITIES	$
PROPERTY, PLANT, EQUIPMENT	$	NON-CURRENT LIABILITIES	$
TOTAL ASSETS	$	TOTAL LIABILITIES	$

Specify period provided_____

5. BALANCE SHEET FOR HIGH PERFORMANCE EXPLOSIVES OPERATION(S): Please provide the balance sheet information (in $000s) as specified below for your latest accounting period. Include only dollar amounts that apply to your high performance explosive operation.

CURRENT ASSETS	$	CURRENT LIABILITIES	$
PROPERTY, PLANT, EQUIPMENT	$	NON-CURRENT LIABILITIES	$
TOTAL ASSETS	$	TOTAL LIABILITIES	$

Specify period provided_____

Please provide any additional comments on Part IV at the end of this document.

PART V: RESEARCH & DEVELOPMENT & TECHNOLOGY

1. TOTAL FIRM RESEARCH AND DEVELOPMENT (R&D) EXPENDITURES: Please enter your firm's total (i.e., not limited to HPE) research R&D expenditures as requested below. Please report your defense-related R&D on the bottom half of the following table. Enter separately the dollar amounts (in $000) expended for: 1) materials, 2) processing development, and 3) product development. (See definition of Research and Development.)

COMMERCIAL RESEARCH AND DEVELOPMENT EXPENDITURES (in thousands of dollars)					
COMMERCIAL	1995	1996	1997	1998 E	1999 E
Materials R&D					
Processing R&D					
Product R&D					
SUB-TOTAL					
DEFENSE RESEARCH AND DEVELOPMENT EXPENDITURES (in thousands of dollars)					
DEFENSE	1995	1996	1997	1998 E	1999 E
Materials R&D					
Processing R&D					
Product R&D					
SUB-TOTAL					
TOTAL					

2. HIGH PERFORMANCE EXPLOSIVE (HPE) RESEARCH AND DEVELOPMENT (R&D) EXPENDITURES: Please enter your firm's related R&D expenditures, **as they apply to your high performance explosives operations**. Please report your defense-related R&D on the bottom half of the table. Enter separately the dollar amounts (in $000) expended for: 1) materials, 2) processing development, and 3) product development. (See definition of Research and Development.)

COMMERCIAL RESEARCH AND DEVELOPMENT EXPENDITURES FOR HPE (in thousands of dollars)					
COMMERCIAL	1995	1996	1997	1998 E	1999 E
Materials R&D					
Processing R&D					
Product R&D					
SUB-TOTAL					

DEFENSE RESEARCH AND DEVELOPMENT EXPENDITURES FOR HPE (in thousands of dollars)					
DEFENSE	1995	1996	1997	1998 E	1999 E
Materials R&D					
Processing R&D					
Product R&D					
SUB-TOTAL					
TOTAL					

3. R&D APPLICATIONS: To what extent is R&D conducted for defense projects applicable to your commercial operations, and to what extent is commercial R&D of use in your defense operations?

4. NEW MATERIALS: Is your firm working on *new* high performance explosives to replace existing ones?

☐ Yes ☐ No

If yes, what types or kinds of high performance explosives are you attempting to replace?

5. SOURCES OF R&D FUNDING FOR HIGH PERFORMANCE EXPLOSIVES OPERATIONS:

Please enter R&D expenditures, by source of funding. The top portion should include all private sources of funding (exclude funding from any U.S. Government agency). The bottom portion should include all federal sources of funding, by specific agency.

Non-U.S. Government Sources	In Thousands of U.S. Dollars				
	1995	1996	1997	1998e	1999e
In-House (profits, loans, etc.)					
Customer: a. Domestic					
b. Foreign					
Joint Ventures: a. Domestic					
b. Foreign					
Govt. (Non-Federal): a. State/Local					
b. Foreign Govt.					
Other: [2] a. Domestic					
b. Foreign					
SUBTOTAL, NON-US GOV.					
U.S. Government Agency	**1995**	**1996**	**1997**	**1998e**	**1999e**
Energy Dept.					
NASA					
Commerce Dept./NIST					
Defense Department:					
Def. Adv. Research Project Agy.					
Armed Services:					
- Air Force					
- Army					
- Marines					
- Navy					
Other: [2]					
SUBTOTAL, US GOVT.					
TOTAL					

[1] e = estimate [2] Please specify "other" category.

6. CEASED RESEARCH AND DEVELOPMENT: Please describe any R&D applicable to your high performance explosives operations that you have ceased since 1995. Indicate the year and the reason R&D efforts were discontinued.

R&D effort_____

Year discontinued_____ Reason for discontinuation_____

_____

R&D effort_____

Year discontinued_____ Reason for discontinuation_____

_____

R&D effort_____

Year discontinued_____ Reason for discontinuation_____

_____

(Attach additional sheets as necessary)

7. WORK WITH EDUCATIONAL INSTITUTIONS: Do you work with any educational institutions (technical colleges, universities) on high performance explosives research and development? Who funds these projects (DARPA, Energy Dept., etc.)? Please list each educational institution, type of R&D done, and source of funding.

Educational Institution_____ R&D description_____

_____

Source of funding_____

Educational Institution_____ R&D description_____

_____

Source of funding_____

Educational Institution_____ R&D description_____

_____

Source of funding_____

(Attach additional sheets if necessary)

Please include any additional comments on Part V at the end of this document.

PART VI: COMPETITIVENESS

1. OVERALL COMPETITIVE PROSPECTS: How do you foresee the *overall* competitive prospects for your firm=s high explosive operations (regarding, for example, price and technology) over the next five years? Circle the appropriate letter below.

Our overall competitiveness should:

A. Improve greatly
B. Improve somewhat
C. Stay the same
D. Decline somewhat
E. Decline greatly

Please discuss the basis for your answer.

_____

_____

_____

_____

_____

A. How do you foresee the domestic competitive prospects for your firm's U.S. high performance explosives operations over the next five years? Circle the appropriate letter below.

Our domestic competitiveness should:

A. Improve greatly
B. Improve somewhat
C. Stay the same
D. Decline somewhat
E. Decline greatly

Please discuss the basis for your answer.

B. How do you foresee the *worldwide* competitive prospects for your high performance explosives operations? Circle the appropriate letter below. Also, please specify each region you discuss.

Our worldwide competitiveness should:

A. Improve greatly
B. Improve somewhat
C. Stay the same
D. Decline somewhat
E. Decline greatly
F. Not applicable (not in and do not plan to enter foreign markets)

Please discuss the basis for your answer.

2. COMPETITION: Who do you consider to be your competition (foreign or domestic) in your high performance explosives product line(s)? Please list domestic, foreign and other competition.

3. TAGGANTS: Have your customers (foreign or domestic) required your firm to include taggants in your high performance explosives? Does that requirement significantly affect the way your firm does business and if so, why?

4. DEFENSE BUDGET CUTS: Please indicate what impacts defense spending reductions have had or will have on your high performance explosive operations. Also, indicate what steps your company is considering to increase efficiency so that your firm can address these reductions (i.e., reduced employment, entered new lines of business, closed plants, consolidated product lines, reduced costs, etc.).

A. Please discuss your firms ability to diversify your high performance explosive defense production operations to commercial operations. Describe any successes or difficulties resulting from diversification. Please indicate if your operation has not attempted diversification and the reasons why.

5. **ENVIRONMENTAL AND SAFETY REGULATIONS:** How have federal, environmental, OSHA and other regulations affected your high performance explosives operations?

A. Please estimate the costs to your firm of meeting federal, state, environmental, OSHA and other regulations over the past five years.

$_____

B. Are there pending **federal** compliance regulations that will cause you to rethink your position in the market?

C. If you operate in more than one state, and their environmental regulations differ, please explain what (if any) affect these differences have on your business.

D. Is there a point where environmental regulations make the high performance explosive business too burdensome to continue?

6. PRODUCT LIABILITY AND INSURANCE RATES: How have the issues of product liability and insurance affected your high performance explosives operations in the past five years?

A. Is there a point at which liability issues make the high performance explosive business becomes too burdensome to continue?

7. EFFECTS OF IMPORTS ON HIGH PERFORMANCE EXPLOSIVE OPERATIONS: How have imports of high performance explosives (including those for your own use) positively or negatively affected your domestic operations?

A. Positive Effects: (e.g. lower costs, expanded markets, improved efficiency, access to foreign markets, etc.) Please explain below:

B. Negative Effets: (e.g. product lines dropped, customers lost, retired capacity, laid-off work force, etc.). Please explain below.

8. **GOVERNMENT POLICIES:** What reasonable adjustments could be made in U.S. Government policies, laws, and regulations that would moderate any competitive disadvantages that U.S. firms might face as a result of these policies, laws, and regulations? (Example - a reduction of red tape in the shipment of explosives..)

9. **GOVERNMENT PARTICIPATION:** How has the federal government assisted/hindered your efforts in the high performance explosives industry? (For example, the government provides R&D assistance; government facilities directly compete with your products, etc.)

10. **MERGERS, ACQUISITIONS, AND TAKEOVERS:** Have mergers, acquisitions, and takeovers in the high performance explosives industry affected your company? If yes, please specify and explain.

11. FUTURE STRATEGIES: Please describe any future strategies your firm is implementing or considering to ensure its long-term participation and competitiveness in the high performance explosive industry. (Ex. mergers, acquisitions, consolidations; conversion: expansion of current operations; exports; testing; R&D; recycling; exit the market; move production offshore etc.)

12. FUTURE IN GENERAL: How do you foresee the future of the high performance explosives industry?

SECTION 2

SUBCONTRACTOR IDENTIFICATION:

Please identify all companies from whom you source parts, components, subassembly, or any other function in support of your production of high performance explosives. Include all types of firms, including distributors. Also identify those firms which are, to your knowledge, the only source for the product or service. Include domestic and foreign firms.

This information may be provided in the format that is easiest for you with your specific computer capabilities.

DATA ELEMENTS

1. Company Name
2. Address
3. Telephone number/FAX
4. Item or Part Name - please be specific
5. Your Part Number
6. Supplier=s Part Number
7. Identify Substitute Item(s) if any exist

CERTIFICATION

The undersigned certifies that the information herein supplied in response to this questionnaire is complete and correct to the best of his/her knowledge. It is a criminal offense to willfully make a false statement or representation to any department or agency of the United States Government as to any matter within its jurisdiction. (18 U.S.C.A. 1001 (1984 & SUPP. 1997))

Signature of Authorized Official _____ Date _____

Type or Print Name and Title of Authorized Official _____

Area Code/Telephone Number _____

Type or Print Name and Title of Person to Contact Regarding this Report _____

Area Code/Telephone Number _____ E-mail Address _____

GENERAL COMMENTS

Is there any other information that we did not request above or that you would like to offer that you believe would be important for this national security assessment of the U.S. high performance explosives industry? Please use the space below to provide any additional comments or information regarding your operations, or other related issues that impact your firm.

_____

_____

_____

_____

_____

_____

Appendix B

Review of SIC 2892

SIC 2892

Explosives

Establishments primarily engaged in manufacturing explosives. Establishments primarily engaged in manufacturing ammunition for small arms are classified in Industry 3482, and those manufacturing fireworks are classified in Industry 2899.

Amatol (explosives)
Azides (explosives)
Blasting powder and blasting caps
Carbohydrates, nitrated (explosives)
Cordeau detonant (explosives)
Cordite (explosives)
Detonating caps for safety fuses
Detonators (explosive compounds)
Dynamite
Explosive cartridges for concussion forming of metal
Explosive compounds
Explosives
Fulminate of mercury (explosive compounds)
Fuse powder
Fuses, safety
Gunpowder
High explosives
Lead azide (explosives)
Mercury azide (explosives)
Nitrocellulose powder (explosives)
Nitroglycerin
Nitromannitol (explosives)
Nitrostarch
Nitrosugars (explosives)
Pentolite (explosives)
Permissible explosives
Picric acid (explosives)
Powder, explosive: pellet, smokeless, and sporting
RDX (explosives)
Squibbs, electric
Styphnic acid
TNT (trinitrotoluene)
Tetryl (explosives)
Well shooting torpedoes (explosives)

Appendix C

Review of SIC 3483

SIC 3483

Ammunition, Except for Small Arms

Establishments primarily engaged in manufacturing ammunition, not elsewhere classified, or loading and assembling ammunition more than 30mm (or more than 1.18) inch), including component parts. This industry also includes establishments primarily engaged in manufacturing bombs, mines, torpedoes, grenades, dept charges, chemical warfare projectiles, and their component parts. Establishments primarily engaged in manufacturing small arms ammunition are classified in Industry 3482; those manufacturing explosives are classified in Industry 2892; and those manufacturing military pyrotechnics are classified in Industry 2899.

Ammunition and component parts, more than 30mm (or more than 1.18 inch)
Ammunition loading and assembling plants
Arming and fusing devices for missiles
Bag loading plants, ammunition
Bomb loading and assembling plants
Bombcluster adapters
Bombs and parts
Boosters and bursters
Canisters, ammunition
Caps, bomb
Chemical warfare projectiles and components
Depth charges and parts (ordnance)
Detonators for ammunition more than 30mm (or more than 1.18 inch)
Detonators: mine, bomb, depth charge, and chemical warfare projectile
Fin assemblies, mortar: more than 30mm (or more than 1.18 inch)
Fin assemblies, torpedo, and bomb
Fuses for ammunition more than 30mm (or more than 1.18 inch)
Fuses: mine, torpedo, bomb, dept charge, and chemical warfare projectile
Grenades and parts
Jet propulsion projectiles, complete
Loading and assembling bombs, powder bags, and shells: more than 30mm (or more than 1.18 inch)
Mines and parts (ordnance)
Missile warheads
Motor shells, more than 30mm (or more than 1.18 inch)
Primers for ammunition, more than 30mm (or more than 1.18 inch)
Projectile forgings, machined: for ammunition more than 30mm (or more than 1.18 inch)
Rockets (ammunition)
Shells, artillery: more than 30mm (or more than 1.18 inch)
Torpedoes and parts (ordnance)
Tracer igniters for ammunition more than 30mm (or more than 1.18 inch)

Appendix D

Census Definitions (1997 Economic Census)

Production Workers

This item includes workers (up through the line supervisor level) engaged in fabricating, processing, assembling, inspecting, receiving, storing, handling, packing, warehousing, shipping (but not delivering), maintenance, repair, janitorial and guard services, product development, auxiliary production for plant's own use (e.g., power plant), record keeping, and other services closely associated with these production operations at the establishment covered by the report. Employees above the working-supervisor level are excluded from this item.

All Other Employees

This item covers nonproduction employees of the manufacturing establishment including those engaged in factory supervision above the line-supervisor level. It includes sales (including driver-salespersons), sales delivery (highway truck drivers and their helpers), advertising, credit, collection, installation and servicing of own products, clerical and routine office functions, executive, purchasing, financing, legal, personnel (including cafeteria, medical, etc.), professional, and technical employees. Also included are employees on the payroll of the manufacturing establishment engaged in the construction of major additions or alterations utilized as a separate work force.

Appendix E

List of BXA Assessments

U.S. Department of Commerce
BUREAU OF EXPORT ADMINISTRATION
OFFICE OF STRATEGIC INDUSTRIES AND ECONOMIC SECURITY
STRATEGIC ANALYSIS DIVISION
PUBLICATIONS LIST

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