

AIR WAR COLLEGE

AIR UNIVERSITY

**AN AMERICAN VITAL INTEREST:
PRESERVING THE NUCLEAR ENTERPRISE SUPPLIER BASE**

by

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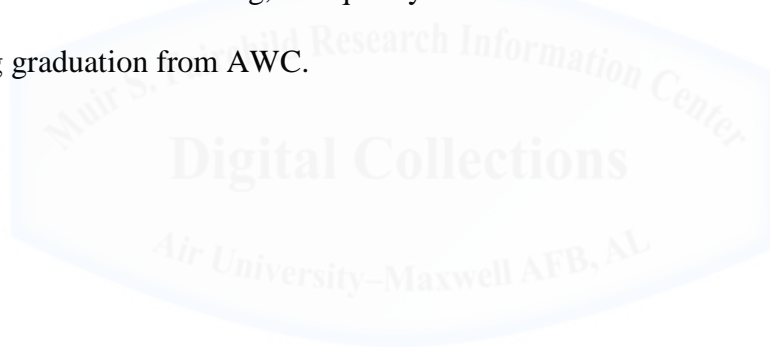
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Biography

Mr. Anton Tran is a federal civilian General Engineer assigned as a student to the Air War College (AWC), Air University, Maxwell Air Force Base (AFB), Alabama (AL). Mr. Tran completed his Bachelor of Science degree in Electrical/Electronics Engineering in 1985, Master's degree in Business Administration in 1992 and 33 graduate hours towards a Master's degree in Engineering Management. He is currently working as a Weapon Quality Engineer at the Department of Energy (DOE)/National Nuclear Security Administration (NNSA). Before joining DOE/NNSA, Mr. Tran was a Senior Project Engineer at Honeywell Aerospace Division where he was involved in hardware and software research and development (R&D), manufacturing, environmental testing, and quality assurance activities. Mr. Tran will return to NNSA following graduation from AWC.



Abstract

The current flexible U.S. nuclear arsenal supporting the national security strategy and defense posture requires the maintenance of a capable nuclear enterprise. However, the nuclear enterprise's supplier base has eroded over time creating a sense of urgency to determine how to sustain a capable nuclear enterprise. President Obama pledged that the U.S. will maintain a safe, secure, and effective nuclear weapons arsenal while pursuing his goal of a world without nuclear weapons, a long-term "path to zero." This paper argues that if the reliable supplier base is not properly preserved, the U.S. may be forced to prematurely go down the "path to zero" or retain lower than optimal stockpile levels because of the lack of manufacturing and acquisition capabilities. This paper intends to identify the current supplier base challenges, explore and examine available options, conduct studies of other industries on their approaches in managing eroding supplier bases, and provide recommendations for preserving the nuclear enterprise's supplier base. While there is no one-size-fits-all solution, if not forced to establish capabilities in-house or accept new part/technology due to obsolescence, the paper recommends that the government opt to choose the widely used practice by other industries: provide incentives to suppliers to foster a positive customer-supplier relationship for preserving the supplier base and sustaining a healthy nuclear enterprise.

Introduction

The United States is the world's pre-eminent superpower due in large part to its conventional and nuclear weapon superiority. It is argued that nuclear weapons have safeguarded America's security for decades during the Cold War by deterring a Soviet attack on the U.S. or its allies. The current flexible nuclear arsenal supporting the national security strategy and defense posture requires the maintenance of a complex nuclear enterprise. An important feature enabling weapon production is a reliable U.S. supplier base providing necessary materials and custom parts to produce nuclear weapon components. However, the erosion of this supplier base has created a sense of urgency to determine how to maintain a capable nuclear enterprise.

In the 2010 National Security Strategy (NSS) and the Nuclear Posture Review (NPR), President Obama stated that he is pursuing the goal of a world without nuclear weapons and supporting additional reductions in the number of U.S. nuclear weapons and the long-term "path to zero."¹ However, as long as nuclear weapons exist, Obama pledged that the U.S. will maintain a safe, secure, and effective nuclear weapon arsenal to deter potential adversaries and assure the security of our allies and partners. Thus, while the "path to zero" is a long-term goal, the U.S. must determine how it can sustain the nuclear enterprise, in particular a reliable supplier base, in an environment where the stockpile is shrinking and the resulting production workload for the supplier base is diminishing.

I argue that if the reliable supplier base is not properly preserved, the U.S. may be forced to prematurely go down the "path to zero" or retain lower than optimal stockpile levels because of the lack of manufacturing and acquisition capabilities. Therefore, in order to maintain the production capability for keeping a safe and effective nuclear weapon arsenal, a more efficient

and reliable manufacturing of weapon components must be possible. With the number of reliable suppliers for these parts diminishing, this paper will illustrate how the U.S. government can sustain the supplier base in order to maintain a viable nuclear enterprise. Four options are explored: (1) Configure the nuclear enterprise to establish in-house manufacturing capabilities to produce piece parts so it can control the availability and quality of the parts; (2) Execute a life-of-program buy of all needed parts for future needs; (3) Subsidize suppliers to manufacture designed parts and to keep production lines open; or (4) Provide incentives to suppliers for producing custom parts and/or retaining the capabilities to re-produce parts for future needs. This paper intends to identify the current supplier base challenges, examine available options, conduct studies of other industries on their approaches in managing eroding supplier bases, and provide recommendations for preserving the nuclear enterprise's supplier base.

The Nuclear Enterprise

During World War II, under the secretive Manhattan Project, U.S. scientists and government personnel designed and produced all nuclear weapon parts. The massive nuclear weapons complex allowed the government to develop the first test device and two nuclear weapons. In the Cold War era, as the nuclear weapons program grew, the nuclear enterprise emerged as a national strategic asset. The nuclear enterprise was fully operated and managed by the U.S. government and its prime contractors (called Management and Operating [M&O] contractors). This healthy nuclear enterprise was sustained until the Cold War ended in the early 1990s. The end of the Cold War brought significant reductions of the nuclear weapons stockpile, and forced the U.S. Department of Energy (DOE) to re-configure the nuclear enterprise infrastructure. After a series of plant closings in the 1990s and outsourcing in the 2000s to

reduce costs, the downsized nuclear enterprise was only able to focus on stockpile sustainment instead of new weapon production (Figure 1).²

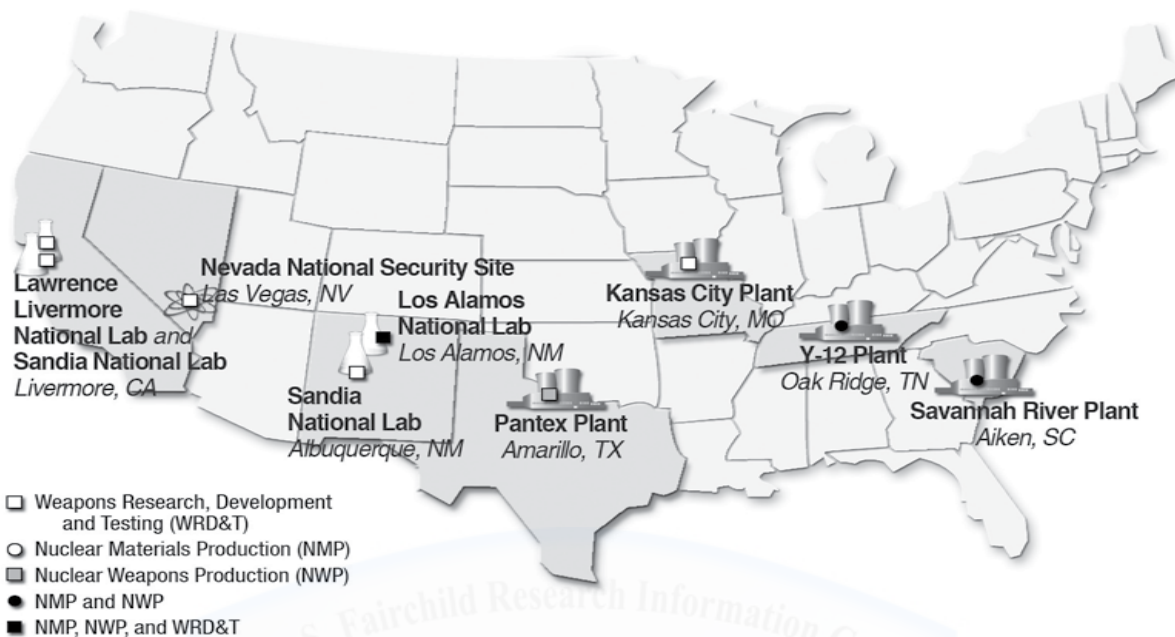


Figure 1. The Downsized Nuclear Enterprise³

In October 1999, the U.S. Congress established a semi-autonomous agency, the National Nuclear Security Administration (NNSA), within the DOE responsible for enhancing national security through the military application of nuclear energy.^{4,5} The law transferred responsibility for managing the nuclear enterprise from DOE to NNSA. NNSA administers the nuclear weapons program through its Office of Defense Programs. To accomplish this mission, NNSA relies on M&O contractors to carry out various tasks at each of the eight nuclear enterprise sites. These tasks include the designing, manufacturing, storing, assembling, nonnuclear testing, qualifying, and dismantling of weapons. NNSA reimburses its M&O contractors under cost-reimbursement-type contracts for the costs incurred in carrying out the missions. The M&O contractors, in turn, may subcontract out major portions of their work, especially in mission-support areas such as constructing facilities. The three national laboratories are responsible for

the designs of nuclear weapons, and so are named design agencies (DAs). There is very limited production of nuclear weapons components at these laboratories. Most weapon components are produced at the four production plants; thus, these plants are called production agencies (PAs) (Figure 1 and Table 1). While most day-to-day activities are managed and operated by the various contractors, NNSA is responsible for planning, budgeting, and ensuring the execution of interconnected activities across the enterprise.

Facility	Location	Primary Responsibility
Los Alamos National Laboratory (LANL)	Los Alamos, NM	Weapons physics design, pit & detonator production
Lawrence Livermore National Laboratory (LLNL)	Livermore, CA	Weapons physics design
Sandia National Laboratories (SNL)	Albuquerque, NM Livermore, CA	Non-nuclear component design, neutron generator production & system integration
Y-12 National Security Complex (Y-12)	Oak Ridge, TN	Uranium
Savannah River Site (SRS)	Aiken, SC	Tritium
Pantex Plant (PX)	Amarillo, TX	Assembly/disassembly
Kansas City Plant (KCP)	Kansas City, MO	Nonnuclear component production/ procurement
Nevada National Security Site (NNSS)	Nye County, NV	National security experiments

Table 1. Nuclear enterprise facilities⁶

The nuclear weapons programs are managed by increasingly complex organizations. The relative large size (cost) of these programs adds an increased political dimension to program management. NNSA weapons program offices are staffed by a mix of military, civilian, and support contractors performing the full range of functions across a program’s lifecycle. There

are generally high levels of teaming among the industry components (at the prime contractor level) because no single entity possesses the resources, capabilities, and political diversity required to fully execute the program itself. NNSA has increasingly relied on M&O contractors for both programmatic and technical capabilities, including program management, requirements formulation and management, systems engineering, and system integration. One of the reasons that the U.S. government relies on contractors for such important program management functions is that the capabilities required to manage these complex systems no longer exist internally.

As in the conventional defense industry, a fundamental change in the nuclear weapon industrial environment is the shift in the role of the prime (M&O) contractors from manufacturers to integrators of components manufactured by subcontractors. Today, the M&O contractors, their suppliers, and their suppliers' suppliers are the critical links in a chain that has significant impact on America's nuclear production capabilities. The current environment demands the need for examining the preservation of the nuclear enterprise's supplier base.

Regardless of the size of the U.S. stockpile, as long as nuclear weapons exist it will be necessary to ensure that weapons will be safe against accidents, be secure against unauthorized use, and function if they are ever employed. This can only be accomplished if steps are taken to maintain the nuclear design, engineering and manufacturing expertise to certify the safety, security, reliability, and effectiveness of all nuclear weapons. The NNSA Stockpile Stewardship Program⁷ has been remarkably successful in enabling the three weapons laboratories to develop advanced research and surveillance capabilities needed to ensure the long-term health of the stockpile. However, the production plants have suffered significant neglect in basic maintenance and comparable improvements until the last few years. There exists a floor below which the capacity and capability of the enterprise cannot go if it is to maintain any competence in nuclear

weapons-related activities. Both the Obama Administration and Congress have recognized this fact and provided the necessary funding to sustain and modernize the nuclear enterprise infrastructure. However, NNSA still relies heavily on industries to supply a vast majority of the non-nuclear piece parts and materials which NNSA builds up into higher assemblies.

Nuclear Enterprise Supplier Base Challenges

Nuclear weapons stockpile management includes the full range of activities related to the development, production, maintenance, and retirement. Although the Department of Defense (DoD) and NNSA share joint responsibility for all U.S. nuclear weapons, NNSA is responsible for the vast majority of weapon components.

Personnel from Sandia, Savannah River, Kansas City, and Pantex provided insight into the significance of supplier base challenges. They offered intriguing arguments on what the U.S. government must consider in order to preserve the supplier base. Challenges include: limited vendor availability for custom parts, timely production and delivery, increasing costs, and quality of delivered parts and supporting documentation. Cost and quality are interrelated due to aggressive production delivery schedules, late design release, or frequent design changes during production.

Honeywell Federal Manufacturing & Technologies – the KCP M&O Contractor – is chosen to do most of the procurement for all eight sites. It accounts for about 85% of total enterprise procurement of the process materials, machined parts, and printed wire boards (PWBs). Honeywell maintains the nuclear enterprise’s Master Approved Supplier List containing all qualified/approved suppliers doing business with NNSA. All NNSA sites use this list. The supplier base for commercial off-the-shelf (COTS) and custom parts does not present significant problems since multiple sources are available and the suppliers are mostly small

companies that rely on Honeywell for business. However, these vendors do present occasional problems in delivering incorrect parts, quantities or documentation. Honeywell continually works with the vendors to ensure parts and paperwork are delivered correctly and timely. Honeywell will partner with responsible design engineers to rectify vendor issues that require multi-agency involvement.⁸ Pantex also experiences similar problems with parts they procure separately from their own vendors.⁹

More difficult challenges involve critical parts procured by other sites. For instance, Sandia ordered a small run of explosive components from a vendor, and there were issues with production, timely delivery and quality. Sandia then selected a replacement vendor; however, the purchase order was similarly a very small percentage of the new supplier's overall business, and quality again became an issue. NNSA tried both less-frequent, but larger, orders and more-frequent, smaller orders (aimed at keeping the supplier in continuous production), but quality did not improve.¹⁰

The significant consolidation throughout the nuclear enterprise at all tiers, especially at the prime level has made the lower tiers increasingly important in parts supply. The M&O contractors have shifted their focus to systems engineering/integration roles rather than component and subsystem development and fabrication. Although the M&O contractors might compete specific capabilities among lower-tier firms, NNSA has little insight into this competition and little direct knowledge of the industrial base beyond key second-tier firms. Thus, NNSA has limited ability to influence this portion of the market that may be an important source of supply.

The government's interest in the manufacturing base should extend throughout the entire tiered structure of contractors, not just to the M&O contractors. Too often, though, the focus is

only at the prime level. While these contractors are vital, the lower tier suppliers are centrally important to a healthy manufacturing base. They are the sources of supply chain that can contribute to the efficiencies or, alternatively, disruptions in nuclear weapon production. Therefore, their health and performance are critical to the viable nuclear enterprise.

Finally, the complexity of the government and industry organizations and the acquisition rules governing them have increased markedly over the years, making it difficult for small businesses to work with NNSA.

Many studies have identified the erosion of the defense industrial base. Dr. Sorenson, an Air War College Professor, presented a Defense Acquisition briefing, showing the decline in naval ship yards and military aircraft companies since 1945 (Tables 2 and 3).¹¹ Research by the American Federation of Labor and Congress of Industrial Organizations (AFL-CIO) published in 2010 revealed that the U.S. manufacturing base has been steadily eroded over the last decade. Its research data show a trend of “the secular decline in U.S. manufacturing competitiveness and technological leadership and the erosion in a wide range of industries critical to national defense.”¹² The AFL-CIO suggests that “only a comprehensive strategy aimed at reversing the erosion in the nation’s overall manufacturing base will be sufficient for preserving and revitalizing the nation’s defense industrial base in the coming decades.”¹³ Several industries and technologies that have experienced significant decline include aerospace, semiconductors, PWBs, machine tools, and advanced materials (e.g., ceramics; composites; magnetic materials; electronic and optical-photonics materials; and polymers). Dr. Sorenson pointed out that the government can limit the erosion rate of the defense industrial base by increasing military sales to American allies and partners.¹⁴ But in the case of nuclear weapons, that type of sales would

be detrimental to U.S. security and world peace. Therefore, in the nuclear enterprise, the supplier base appears to have no upside potential.

Yards Capable of Building Real Ships

1944-45	2011
<ul style="list-style-type: none"> • Philadelphia Naval Yard • Todd Pacific Shipyards, WA • New York Shipbuilding, Camden, NJ • Newport News Shipbuilding, Virginia • Federal Shipbuilding, Kearney, NJ • Bethlehem Shipbuilding, Quincy, MA • New York Naval Shipyard, Brooklyn, NY • New York Navy Yard, NY • Norfolk Navy Yard, VA • Electric Boat Corporation, CT • J.A. Jones Construction, GA • California Shipbuilding, CA • Permanente Metals, CA • Delta Shipbuilding, LA • Bethlehem Fairfield Shipyards, MA • Oregon Shipbuilding, OR • New England Shipbuilding, ME • St John's River Shipbuilding, FL • Kaiser Shipbuilding, WA • Walsh-Kaiser, RI • William Cramp & Sons, PA 	<ul style="list-style-type: none"> • Bath Iron Works (ME) • Ingalls (Pascagoula, MS) • Arondale (New Orleans, LA) • Gulfport (Gulfport, MS) • Austal USA Shipbuilding (AL) • Marinette Marine (WI) • Huntington-Ingalls Newport News (VA) • Electric Boat (CT)

Table 2. The Shrinking Ship Yards

U.S. Contractors Capable of Building Military Aircraft

1945	2010
<ul style="list-style-type: none"> • Boeing • Douglas • Fairchild • Grumman • Lockheed • Ryan • Vultee • Consolidated • North American • Brewster • Chance-Vought • Curtiss • Republic • Bell • Northrop • McDonnell 	<ul style="list-style-type: none"> • Lockheed-Martin • Boeing • Northrop-Grumman

Table 3. The Reduction of U.S. Military Aircraft Contractors

Options

Among the four options explored to preserve the nuclear enterprise supplier base, the first is establishing all production internally. In order to decrease reliance on external suppliers, the U.S. can establish all manufacturing capabilities in-house, like it did in the Manhattan Project. This option would allow the nuclear enterprise full control of part availability and quality. Although possible, this option is rather expensive. In 1997, after realizing thirteen of fifteen radiation-hardened microelectronics suppliers had left the business and the remaining two faced uncertain futures, Congress appropriated \$30M to DOE to develop an in-house, contingent radiation-hardened microelectronics capability even though the stated preference was for the private sector to do the work.¹⁵ In addition, Congress directed DoD and DOE to jointly “initiate a program to maintain a limited in-house production capacity to fill near-term critical needs, should they arise. The joint program should use the Department of Energy’s existing facilities and should maximize use of existing fabrication facilities.”¹⁶ Even if in-house capability is established, the life-time operational cost can be tremendous. Given the current economic climate and other competing national priorities, this will not be a viable option.

The second option is to execute a life-of-program procurement plan for all parts based upon estimated future needs. With a schedule of nuclear weapon Life Extension Programs (LEPs), NNSA can project all the parts that it needs to purchase for the replacement of weapon components. This option can save the U.S. a significant amount of money since there is a surge in LEP activities presently and NNSA can leverage off that with higher purchasing and bargaining power due to an increased volume. However, this can be a rather risky endeavor since we cannot really predict what the political environment will be in the future. The government has reduced production quantities (e.g., F-35s) or even cancelled programs (e.g.,

W61, B90, and Robust Nuclear Earth Penetrator programs) after initiating them. Purchasing millions of dollars' worth of parts when future needs are uncertain is risky. New treaties may be signed and stockpile reductions may be accelerated. Weapon-specific parts will be wasted and additional funds will be needed for disposing them. Additionally, the impact of long-term storage on the quality of these parts is not fully known.

The third option is to directly, or indirectly (via M&O contractors), subsidize suppliers to manufacture designed parts and keep production lines open. Subsidizing suppliers could bring manufacturing costs down and make it more attractive for them to do business in the limited nuclear weapon industry. More than a trillion dollars have been spent on government subsidies to preserve vital national assets and industries (e.g., financial and automotive bailouts, U.S. Postal Service, Amtrak, and agriculture). If nuclear weapons continue to be integral to our national security and defense strategies, subsidizing the nuclear enterprise supplier base, and in a broader sense, the defense industrial base, is the price we may need to pay.

The fourth option is to have the government provide incentives to suppliers to produce custom parts and/or retain the capabilities to re-produce parts for future needs. The government can put forth incentives in the prime contracts to reward M&O contractors for successful supply chain management. The contractors should be required to have a more robust oversight process to ensure the quality of their suppliers. The government can adjust progress payments to incentivize M&O contractors' performance. Furthermore, we need to make the M&O acquisition systems more interactive and collaborative – one way is to use 'lean thinking' and 'value stream' the entire weapon system acquisition process and procurement of nuclear weapon parts.¹⁷

Supplier Base Challenges In Other Industries

Nuclear weapon parts have unique characteristics. They are considered high-value, high-reliability, high-consequence, high-regulation, no-fully-assembled-system-test, and low-volume items. There is no other part that can exactly match the nuclear weapon profile. During this research, the author attempted to investigate how other industries manage their supplier base and what challenges exist. These include automobile, defense space and missile, defense avionics, and United Kingdom (UK) nuclear weapon industries.

Automotive

The author visited the Hyundai Motor Manufacturing Alabama (HMMA) on 5 December 2011 to investigate the commercial automotive industry customer-supplier relationship.

Automobile safety parts (i.e., brakes and airbags) are considered high-reliability, high-consequence, and high-regulation items, matching some of the nuclear weapon parts characteristics.

HMMA Supplier Quality personnel work very closely with their suppliers to ensure the quality and functionality of the delivered parts meet all requirements. All potential suppliers are initially screened with a “run at rate”: the suppliers must demonstrate that they can meet HMMA’s demand of producing at least 400 quality parts every four hours. All suppliers are audited annually using the Hyundai’s “five-star” audit system. A “five-star” supplier gains a top-priority preference for future business with Hyundai. This incentive allows Hyundai to form a positive partnership with its suppliers. HMMA has about 80 suppliers with approximately three to five “five-star” suppliers. HMMA Supplier Quality personnel are also members of the plant-wide Part Quality (PQ) Team that monitors general assembly lines 24/7. Any quality or assembly problems will result in an immediate production line shutdown or plant stoppage. Therefore, it can be costly if a bad part (e.g., wrong color, unfit brake or trim pieces) is received

from the vendors. If a line is down, the PQ Team must meet with upper management immediately to address the issues. If the vendor problems arise and are significant enough, HMMA personnel will visit and stay at the vendor site until the problems are resolved.¹⁸

This example illustrates a customer-supplier partnership to develop and retain a pool of high quality and reliable suppliers using the ‘top-priority’ business incentive. NNSA can apply this model by directly providing M&O contractors incentives to establish this approach with their suppliers or indirectly provide the funding to the M&O contractors for incentivizing their vendors. (For more on Hyundai, see Appendix A.)

Defense Space and Missile

The U.S. space and missile industry closely resembles the nuclear weapon industry – production relies on access to high-value, high-consequence, high-reliability, high-regulation, and low-volume items. However, a major difference is that replacement satellites can be built and launched, while failure of a nuclear weapon to detonate when authorized, on the other hand, is unacceptable. As in the nuclear weapon industry, the U.S. space and missile industry has seen a dramatic erosion of supplier base due to a decreasing number of launches in America. Furthermore, with the continued pressure on the launch industry to cut costs, and the resulting consolidation of launch vehicles and programs, the industry has also seen a consolidation of vendors. There are currently only two vendors for command receivers, three major ordnance systems vendors, and four major battery manufacturers for launch vehicles and spacecraft.

Engine and solid rocket motor consolidation is also occurring. Currently, only a handful of U.S. rocket engine manufacturers remain. Pratt-Whitney/Rocketdyne is the only maker of LOX/LH2 rocket engines in America and until recently was also the only maker of LOX/RP-1 engines as well. SpaceX is now making the Merlin 1 LOX/RP-1 engine. Aerojet is marketing (and selling to Orbital for the Taurus II first stage) modified Russian LOX/RP-1 engines, and

ULA/Atlas flies Russian-built RD-180 engines. Aerojet is also continuing to make hypergol engines. There are now only two major solid rocket motor manufacturers in America (ATK and Aerojet). One unpleasant result of this vendor consolidation is that an anomaly within one program now has a ripple effect and can (and often does) result in grounding other launch vehicles due to the fact that every vehicle shares some parts/vendors with other vehicles.¹⁹

Many satellites rely on space-rated, mechanical relays. However, as most other electronics industries have transitioned or are transitioning away from mechanical relays to solid state switching technology, the number of relay vendors has dropped drastically. The space industry is therefore forced to make the mechanical-relay-to-solid-state transition since reliable, space-rated relays are no longer available. Instead of driving technological innovation, the space industry is being forced to move away from proven, albeit older, technology and adopt largely unproven, but available, hardware.

The defense space and missile industry demonstrates how supplier base reductions can threaten existing programs. Obsolete/sunset technologies have forced the space program to introduce unproven replacement technologies. These scenarios mirror what are happening in nuclear weapon program: DAs are compelled to accept part and technology changes that have potential impacts to designs that cannot be fully tested. The option that the U.S. selects should be considered through a thorough cost/benefit analysis because sometimes the industry just has to accept what is only available.

Defense Avionics

The defense avionics industry somewhat resembles the nuclear weapon industry – parts tend to be fairly high-value, high-consequence, high-reliability, high-regulation, and low-volume

items. However, a major difference is that avionics systems can be fully tested before they are fielded. The defense avionics industry has also witnessed a dramatic erosion of supplier base.

In this industry, it is noted that suppliers of old parts are hard to find. For instance, the Army had a hard time finding replacement parts for the memory chips used on its old OH58 helicopters. These helicopters' lives have been extended, and they were/are heavily employed in Iraq and Afghanistan operations. Bell Helicopter is the prime contractor, and Honeywell Aerospace is the subcontractor responsible for the avionics system and the sole supplier of the avionics graphics card (but not the memory chip that goes on the card). The Army required additional graphics cards to extend the helicopter's life for 10 additional years.

In 1990, Texas Instruments notified the Army they would discontinue production of the TMS4461 graphics memory chip. The Army pursued a lifetime purchase in order to support repairs and production until aircraft end-of-life. The Army procurement office estimated future production for 200 Display Processor units, each containing 10 memory chips. The following three possible options were proposed by Honeywell, and considered by the Army for continuing the support of the 200 production units yet to be built and the 360 units already fielded.

- **Option #1** – Procure sufficient memory chips to meet future production needs (2,000) and estimate the number required to support field repairs (200). The procurement office calculated the life-time purchase of these 2,200 memory chips at a cost of \$22,000.
- **Option #2** – Fund the development of a memory chip replacement. Using common DRAM memory devices, design an interface which will act as a 'gasket' between the memory and the graphics processor to emulate the functionality of the 4,461 memory device. Development costs would be approximately \$200K plus re-qualification of the

unit, \$30K. No operational software would be impacted. Total cost was approximately \$230K plus the cost of the DRAM memory.

- **Option #3** – Redesign the graphics processor card with up-to-date parts. Cost of a card re-design would be approximately \$360K, the cost of software development would be \$1.2M, and the cost to re-qualify the unit was estimated at \$30K. Total cost was about \$1.59M.

Options #2 and #3 were rejected because future production of this aircraft was limited to 200 airships. The new Light Helicopter Experimental (LHX) development program was well underway and was designed to replace the OH58s. The Army procurement office elected to fund the \$22K life-time buy, and stored the parts at Honeywell for future use.²⁰

This case demonstrates that a life-of-program procurement can be made at the development stage while the parts are still available. Like Hyundai, Honeywell provides incentives to their ‘preferred’ suppliers. If the supplier is small, but critical to success, Honeywell can negotiate a mutually beneficial agreement and designate the supplier as ‘preferred’. If the supplier is large and is not dependent upon Honeywell’s business, then they are more likely to pursue a lifetime buy. Options exist based upon size of the order, technology of the parts, and the relationship between the contractor and its supplier. Adapting this flexibility to nuclear weapon industry can be advantageous.

UK Nuclear Weapon

The UK nuclear weapon enterprise very closely resembles that of the U.S. The UK procures very few nuclear weapon parts from the UK or European commercial market place. In terms of managing procurement for their processes, equipment and infrastructure, the UK has established a business process (CPP3500, *Business Continuity – Supply Chain*) which defines how the Atomic Weapons Establishment (AWE) ensures that a failure within its supply chain

does not disrupt AWE operations. It also establishes a 'Platinum Partners' scheme that seeks to build excellent relationships with key suppliers that deliver long-term mutual benefit. This scheme is similar to what Hyundai's 'five-star' suppliers and Honeywell's 'preferred' status.

As AWE is managed and operated by a Joint Venture Company (Lockheed Martin, Jacobs Engineering and Serco), it is also building enhanced relationships with the supply chain through these organizations. For instance, AWE is engaging with Lockheed Martin UK on heat shield work and development. It has re-energized their relationship with Brush Wellman on Beryllium Supply, and undertaken energetic materials development with Roxcel. It is developing a relationship with the French nuclear program to share certain high-cost technologies. Finally, with regard to 'Platinum Partners,' AWE currently focuses on infrastructure development as this is the priority program at AWE (e.g., new facilities construction). AWE believes that leverage through larger (and more influential) parent organizations, partners, or other corporate associations seems to be a way forward in securing sustained and enduring small-volume purchases from suppliers. Both AWE and UK Ministry of Defence (MoD) actively pursue links with industry partners in Europe and worldwide through academic collaborations and other interface opportunities. This, of course, could lead to knowledge of and access to a wider supplier base.²¹

Leveraging off parent organizations is a widely used practice to gain economy of scale. Furthermore, collaborating with other industries/academia introduces opportunities to be more cost effective and resourceful. For example, it was noted that Pacific Scientifics is doing both the space and missile and nuclear weapon work; however, NNSA and DoD have not done much interagency collaboration, a practice used by UK, to preserve this supplier or leverage off each other in working with common suppliers.

Recommendations and Conclusion

The U.S. is clearly dependent on its supplier base to maintain an effective nuclear arsenal. Although America used to be able to count on multiple reliable sources for providing parts, the decline in U.S. manufacturing and the erosion of industries critical to national defense over the past several decades have fundamentally hurt the domestic capacity to supply critical products for national security. The probability of America losing all capability to manufacture parts for nuclear components is still relatively low, but the consequences of such a situation would be catastrophic. The findings in this paper point to important implications regarding public policies for strengthening the nation's nuclear weapon supplier base. There are only a few reliable firms willing to keep their place in the nuclear weapon industry. However, this endeavor requires great investment of capital. Only a comprehensive sustainment strategy aimed at maintaining a reliable supplier base will be sufficient for preserving and revitalizing the nation's nuclear enterprise until the "path to zero" is determined. DoD has successfully done five-year gap assessments periodically to estimate the defense industrial capabilities and supplier base availability.²² NNSA should consider conducting the same or leverage off those assessments and initiatives to ensure its viable technologies and supplier base continue to exist. Recognizing the scope of supplier base erosion is the first step towards developing creative solutions to preserve parts availability for the nuclear arsenal.

There is no one-size-fits-all solution for preserving a reliable supplier base. Flexibility in options should be considered when a technology, part or supplier must be preserved. With further study, a decision matrix may be developed that takes into consideration the type of part/technology, the number of available suppliers, and the contractor-supplier relationship in order to provide a starting point for considering the best option.

One option is to buy the entire parts requirement in a single life-of-program buy to save money. This option should be considered when we buy custom products from a very limited supplier base where we have little leverage over the supplier. However, this option does not guarantee the preservation of suppliers for future needs.

The incentives option is widely used by numerous industries. The government can tailor this approach by putting forth incentives in the prime contracts to reward contractors for successful supply chain management. The M&O contractors should be required to have a more robust oversight process to ensure the quality of their suppliers. The government should also develop capabilities to gain insight and have knowledge of the entire tiered structure of contractors. We need to make the M&O systems more interactive and collaborative, instead of operating independently. One way is to apply 'lean thinking' and 'value stream' the entire weapon system acquisition process and the overall government procurement of nuclear weapon parts to establish an integral link of supply chain and partnership: government, prime contractors and suppliers.

Sometimes, there may be certain instances when government must develop in-house production capability if no vendors exist that are capable or willing to provide necessary parts.

Finally, the problem and solution may not be with the suppliers and the existing technologies used in nuclear weapons. It is possible that DAs develop more robust designs that can accommodate variations found in COTS parts and work with the suppliers to utilize these parts in nuclear weapons. Further research needs to be conducted to study the implications of these alternatives. In the meantime, implementation of the incentives option can help the U.S. preserve the supplier base and sustain a viable nuclear enterprise until the "road to zero" is ultimately achieved.

Appendix A

The Rise of Hyundai

I chose Hyundai in this research because in the past few years, Hyundai has become the world's fastest-growing carmaker. Americans are well known for their love of American speed, German ingenuity and precision, and Japanese quality. How can a Korean car company that failed miserably in 1986 become a nightmare for all other automakers? I performed this research to learn what Hyundai does that makes them so uniquely successful now as compared to the past. I found out it's their speed, their ways of embracing the employees' inputs and customers' feedbacks, their hunger to get better, and their willingness to change and take risks. We can all learn a lot of things from this mighty company.

Hyundai was founded by Chung Ju Yung in 1947 and Hyundai Motor Company was later established in 1967. In 1986, Hyundai began to sell cars in the United States, but the poor quality of the Excel hurt Hyundai's image. In 1999, Chung Ju Yung transferred the leadership of Hyundai Motor to his son, Chung Mong Koo, and Hyundai began to overhaul its image in an attempt to establish itself as a world-class brand. Hyundai invested heavily in the quality, design, manufacturing, and long-term research of its vehicles. It added a 10-year or 100,000-mile warranty to cars sold in the United States and launched an aggressive marketing campaign to ascertain customers that its quality has improved. These efforts paid off, Hyundai improved its J.D. Power and Associates "initial quality" ranking from 13th in 2008 to 4th in 2009 and sales has increased ever since.

Hyundai attributes its success to the renewed corporate culture and philosophy: easy access to top management, risk taking, thrive on improvement opportunities, appreciate customer feedback, and embrace late change responsiveness. During my research, I found out how Toyota

studied Hyundai and that it could not duplicate the Hyundai's way of doing business. Toyota team selected the Hyundai Santa Fe SUV with the steepest rate of quality improvement (measured by J. D. Power), performed analysis to determine what was between Santa Fes built in four successive model years and took them apart to study their evolution. Toyota's way is to bundle changes for implementation at each major model change cycle (Honda also does it this way). What was discovered during the Santa Fe analysis is that Hyundai makes 100-200 product changes every year in response to customer and dealer suggestions to fix that or to improve this. So a key difference between Hyundai and Toyota is continuous design change to ensure the quality and performance of their products even when it means extra work for the Hyundai engineering team.

Hyundai is also a very lean organization. At Toyota, there are more than forty people with vice president and above titles; Hyundai has only five at that level. The minimum bureaucracy allows Hyundai to swiftly make decisions and achieve a four-year full product replacement cycle versus a six-year cycle for Honda and Toyota cars.

Hyundai came and built HMMA in 2002. HMMA produces 1,300 cars per day. This plant elects to procure safety parts from U.S. suppliers that can meet the U.S. National Highway Traffic Safety Administration (NHTSA) regulations. The NHTSA is the U.S. government agency responsible for implementing and enforcing the National and Motor Vehicle Safety Act of 1966 and certain other laws relating to motor vehicle safety. NHTSA has published Federal Regulation (FR)-recommended best practices for importers of motor vehicles and motor vehicle equipment to enhance their safety.

HMMA uses the NHTSA-recommended ISO/TS16949 Standard to establish effective quality control mechanisms and workmanship. ISO/TS16949 was jointly developed by the

International Automotive Task Force (IATF) and is the international quality management system applied to the design and development, production, and the installation and service of automotive-related products. In November 2006, HMMA was accredited as the only U.S. automotive plant to gain the TS16949 accreditation as an Original Equipment Manufacturer (OEM).

Hyundai's focus on design, engineering, marketing, manufacturing, quality, supplier, and customer-relation aspects are amazingly well thought of and executed. It is no wonder why this car company turned its fortune around so quickly and has become a business case model for many other companies, not just in the automotive industry, to study.



Endnotes

¹ Department of Defense (DoD), *Nuclear Posture Review Report*, 41.

² DoD, *Nuclear Matters Handbook*, 93-103.

³ *Ibid.*

⁴ Government Accountability Office (GAO), *NATIONAL NUCLEAR SECURITY ADMINISTRATION – Security and Management Improvement Can Enhance Implementation of NNSA Act*, 1.

⁵ NNSA Act, Public Law 106-65.

⁶ Spence, *Zero Nuclear Weapons and Nuclear Security Enterprise Modernization*, 123.

⁷ DoD, *Nuclear Matters Handbook*, 103-108.

⁸ Author's Interview with Honeywell FM&T Senior Purchasing Manager, December 2011, whole section.

⁹ Author's Interview with B&W Pantex Supplier Quality Department Manager, December 2011, whole section.

¹⁰ Author's Interview with NNSA Sandia Site Office Weapon Quality Manager, December 2011 – January 2012, whole section.

¹¹ Sorenson, *The Politics of Defense Acquisition and the Defense Budget*, slides 39-40.

¹² Yudken, *Manufacturing Insecurity – America's Manufacturing Crisis and the Erosion of U.S. Defense Industrial Base*, 5-16.

¹³ Yudken, *Manufacturing Insecurity – America's Manufacturing Crisis and the Erosion of U.S. Defense Industrial Base*, 16.

¹⁴ Sorenson, *The Politics of Defense Acquisition and the Defense Budget*, slides 41-42.

¹⁵ Senate Report SR-105-44, 102: "Up to \$30,000,000 is provided to develop an in-house, contingent source of radiation-hardened microelectronics. It is not the Committee's preference that the Department supply its own radiation-hardened microelectronics. To the contrary, the Committee would prefer that the private sector be positioned to supply radiation-hardened microelectronics, an essential component for a variety of Department of Energy applications. However, in recent years, 13 of 15 radiation-hardened microelectronics suppliers have left the business, and the remaining 2 face an uncertain future. Given the importance of these components, the Committee directs the Department to develop a capability, should it be necessary, to rapidly transfer production capability to private sector vendors to produce radiation-hardened microelectronics."

¹⁶ Senate Report SR-105-29, 429: "The committee is concerned about the Department of Energy's ability to ensure an adequate supply of radiation-hardened microelectronics for nuclear and non-nuclear weapon systems. The committee notes that radiation-hardened microelectronic components are critical elements in nuclear weapons and other defense systems. The committee further notes that many radiation-hardened microelectronic parts in current weapon systems were made by suppliers that are no longer in the business. At the present time, only two vendors are available to bid on production of new radiation-hardened circuits required for DOE's stockpile life extension program. In many cases, there may be as long as a three-year lead time to obtain replacement parts. To address this problem, the committee believes the Secretary of Energy and the Secretary of Defense should enter into an agreement to form a national defense electronics partnership to focus on those measures necessary to maintain a supply of radiation-hardened microelectronic components for current and future defense uses. The program should include an

effort to develop technologies that can be transferred to private industry as a way of easing the entry of new suppliers into this specialized market. In addition, the Departments of Defense and Energy should initiate a program to maintain a limited in-house production capacity to fill near-term critical needs, should they arise. The joint program should use the Department of Energy's existing facilities and should maximize use of existing fabrication facilities.”

¹⁷ Womack and Jones, *Lean Thinking*, 252, 276-282 and 327.

¹⁸ Author's Interview with Hyundai Supplier Quality Development Manager, December 2011, whole section.

¹⁹ Author's Interview with DoD 45 Space Wing/Safety Office Chief Engineer, December 2011, whole section.

²⁰ Author's Interview with Honeywell Aerospace Staff Engineer, December 2011, whole section.

²¹ Author's Interview with UK AWE Divisional Product Quality Assurance Manager and MoD Head of Product Quality, whole section.

²² GAO, *DOD Assessments of Supplier-Base Availability for Future Defense Needs*, 1-2.



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