

**Spring 2012
Industry Study
Final Report
*Strategic Materials Industry***



The Industrial College of the Armed Forces
National Defense University
Fort McNair, Washington, D.C. 20319-5062

ABSTRACT: US industry's access to adequate "strategic materials," including domestically and globally produced mineral resources, remains a key component of US national security. Interest in the nation's minerals is rooted in the establishment of the US Geological Survey in 1879 and the Bureau of Mines in 1910. With the post-World War II advent of globalization and world trade, US national security policy increasingly relies on the capabilities of its domestic defense sector and an international commercial industrial base. This research hypothesizes that the United States would strengthen its national security interests by: redefining the concept of a National Defense Stockpile (NDS); improving the understanding of current US policy, recycling and the environment; refining the concept of multinational supply chain management; adopting a more holistic policy approach that considers the US strategic materials industry and its relationship with emerging technologies and the international economic system; and creating enabling mechanisms for networks among the US government, industry, academia and international partners. This paper also discusses strategies for mitigating national security risks related to "strategic materials."

Lt Col Dominic Bernardi – United States Air Force
CDR Jeffrey Buss – United States Navy
CDR Nicole Chambers – United States Navy
CAPT Yvette Davids – United States Navy
Mr. Christian De Angelis – United States Department of State
Lt Col Paul Henderson – United States Air Force
CDR John Howrey – United States Navy
LTC Thomas McLeary – United States Army Reserve
COL Armida Montemayor – United States Army
CAPT Juan Munoz, International Fellow – Mexico
Mr. Toshihisa Nabeta, Industry Fellow – Mitsubishi Corporation, Japan
Mr. John Riedel-Alvarez – Department of the Navy
COL Michael Thurston – United States Army
Lt Col Brian Toth – United States Air Force
Lt Col Alice Trevino – United States Air Force

CAPT David Schnell – United States Navy, Faculty
COL Kelly Ward – United States Army, Faculty
CAPT (retired) Jeanne Vargo – United States Navy, Faculty Lead

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ACRONYMS AND ABBREVIATIONS

ARC - Antarctic Resource Center
 BAA - Buy American Act
 CBO - Congressional Budget Office
 CFIUS - Committee on Foreign Investment in the United States
 DLA - Defense Logistics Agency
 DLASM - Defense Logistics Agency Strategic Materials
 DoC - Department of Commerce
 DoD - Department of Defense
 DoE - Department of Energy
 DoL - Department of Labor
 DoS - Department of State
 DPA - Defense Production Act
 DPAS - Defense Priorities and Allocations System
 EEZ - Exclusive Economic Zone
 ELI - Environmental Law Institute
 EPA - Environmental Protection Agency
 EU - European Union
 FTA - Free Trade Agreement
 FY - Fiscal Year
 GATT - General Agreement on Tariffs and Trade
 HAZMAT - Hazardous Material
 HSPD - Homeland Security Presidential Directive
 IARPC - Interagency Arctic Research Policy Committee
 ICAF - Industrial College of the Armed Forces
 ITAR - International Traffic in Arms Regulations
 LED - Light Emitting Diode
 MEMS - micro-electromechanical systems
 MOU - Memorandum of Understanding
 NAICS - North American Industry Classification System
 NAFTA - North American Free Trade Agreement
 NDAA - National Defense Authorization Act
 NDS - National Defense Stockpile
 NEPA - National Environmental Policy Act
 NMA - National Mining Association
 NNS - Near Net Shape
 NSPD - National Security Presidential Directive
 NSTC - National Science and Technology Council
 PPI - Policy Potential Index
 R&D - Research and Development
 RE - Rare Earths
 REE - Rare Earth Elements
 SCM - Supply Chain Management
 SecDef - Secretary of Defense
 SMCRA - Surface Mining Control and Reclamation Act
 SMP - Specialty Metal Provision



SMPB - Strategic Materials Protection Board
SMSP - Strategic Materials Security Program
SQM - Sociedad Química y Minera de Chile S.A.
STEM - Science Technology Engineering Mathematics
TFBSO - Task Force for Business and Stability Operations
UNCLOS - United Nations Convention on the Law of the Sea
US - United States
USGS - United States Geological Survey
USTR - United States Trade Representative
US ARC - United States Arctic Research Council
WTO - World Trade Organization



PLACES VISITED

Domestic Locations:

Colorado:

Colorado School of Mines, Golden, CO
Henderson Molybdenum Mine, Empire, CO
Molycorp, Inc., Greenwood Village, CO

Ohio:

Advanced Materials Group (ADMA), Hudson, OH
ALCOA Forgings and Extrusions, Cleveland, OH
Materion, Elmore, OH
Timken Company, Canton, OH
RTI International Metals, Inc., Niles, OH

Maryland:

Army Research Laboratory, Aberdeen, MD

Pennsylvania:

Carpenter Technologies, Reading, PA
Titanium Metals Corporation, Morgantown, PA

Virginia

United States Geological Survey (USGS), Reston, VA

Washington, DC

Embassy of Chile
Senate Committee on Energy and Natural Resources, Dirksen Senate Office Building

International locations:

Chile:

Chilean Copper Commission - COCHILCO (Comision Chilena del Cobre), Santiago
Chuquicamata Copper Mine, Atacama region
Embassy of the United States
National Mining Society - SONAMI (Sociedad Nacional de Minería), Santiago
National Copper Corporation of Chile - CODELCO (Corporacion Nacional del Cobre), Santiago
SQM Solar Evaporation Ponds (Lithium and Potassium), Atacama region

Dominican Republic:

Ministry of Mines, Santo Domingo
Office of the Geological Survey, Santo Domingo
Perilya, Cerro Maimon Mine, Maimón
Xstrata Nickel, Falcondo nickel mine, Bonao

**ORGANIZATIONS THAT PROVIDED REPRESENTATIVES TO BRIEF THE
STRATEGIC MATERIALS INDUSTRY STUDY SEMINAR**

Defense Logistics Agency Strategic Materials (National Defense Stockpile)
J.A. Green and Company
Materials Manufacturing and Prototype Technology, US Army Armament and Research
Development and Engineering Center (ARDEC), Picatinny Arsenal, New Jersey
National Mining Association
Office of the Director of Defense Procurement and Acquisition Policy, Contract Policy and
International Contracting, Office of the Under Secretary of Defense for Acquisition,
Technology, and Logistics
Office of Technology Transition, Office of the Under Secretary of Defense for Acquisition,
Technology, and Logistics
Office of the Undersecretary of Defense for Science and Technology
Office of Industrial Base Policy, Office of the Deputy Assistant Secretary of Defense for
Manufacturing and Industrial Base Policy
The Institute for Defense Analyses
The PEW Charitable Trusts Environment Group
Traxys Worldwide
US Geological Survey National Minerals Information Center



"Here in the United States of America we must not err again by being slow to recognize the strategic value of the mineral resources within our own borders."

–George Otis Smith, Geologist and former USGS Director, 1919¹

CHAPTER I: INTRODUCTION

Recognition of the importance of the nation's mineral reserves to national security pre-dates George Otis Smith's above quoted caution. As early as the 1830s, renowned geologist George Featherstonhaugh recommended that the United States (US) government develop a geological map of the nation's mineral reserves.² The advent of increased globalization and the interconnectedness of world trade following World War II led to US national security strategists recognizing that certain materials required not only a domestic awareness about supply source, but a global awareness of mineral resources and third country production capability and capacity. US policymaking has continued in that direction. This reality necessitates that policy strategists consider an expanding range of complexities that affect national security. Chief among these considerations are the implications associated with securing a supply of strategic minerals and the industrial capability to manufacture materials from them. The realities of a globalized world and the geopolitical complexities that accompany it must inform US policy.

It is imperative to define and agree upon the spectrum of national security when "strategic material" policy decisions are being made. With the premise that US industry's access to adequate strategic materials is a key component of national security, this research hypothesizes that the United States would strengthen its national security interests by: redefining the concept of a National Defense Stockpile (NDS); improving the understanding of the relationships among recycling, the environment and appropriate US policies; refining the concept of multinational supply chain management; adopting a more holistic policy approach that considers the US strategic materials industry and its relationship with emerging technologies and the international economic system; and creating enabling mechanisms for networks among the US government, industry, academia and international partners. This paper also discusses strategies for mitigating national security risks related to "strategic materials."

Scope and Approach

In compiling this research, the authors performed an extensive review of printed and electronically available materials, to include previous ICAF Industry Study research, strategic material industry and related publications, congressional testimony, articles and reports. In addition, the authors interviewed experienced representatives from the private sector and US government officials involved with strategic materials. The feedback and information collected from these resources and professionals was used to develop the recommendations in this report.

The team participated in learning and education exchanges throughout the supply chain, learning about ore extraction, oxidation, metal refinement, alloying, forging, production and manufacturing. Tours and outreach efforts included visits to defense and industry laboratories and meetings with academic experts, research scientists and production engineers. The team also studied mineral extraction and processing methods in Chile and the Dominican Republic.

CHAPTER II: STRATEGIC MATERIALS INDUSTRY DEFINED

The materials industry encompasses multiple sectors and the full range of material production (e.g., exploration, mining, ore processing, refining, conversion and manufacturing). With 118 elements on the periodic table, many of which exist in multiple mineral forms that can be

combined and developed into various materials, the breadth of potentially strategic material possibilities are nearly limitless. To analyze the materials industry with fidelity, it is important to establish the scope of which materials to examine. The authors narrowed down a myriad of industries that feed materials into the defense industrial base to identify segments most important for national defense. This study focused on non-fuel materials, predominately in the specialty metals domain, that have importance to major defense suppliers supporting US national security.

The complex interdependencies of these different industries complicate the task of determining exactly what should be considered "strategic" and/or "critical" materials. No North American Industry Classification System (NAICS) code for materials critical to national defense exists, nor is there a clear cut Wall Street-defined defense material sector that neatly fits the "industry" in question. Thus, the "industry" examined includes widely disparate businesses ranging from exploration to mining, forging and nanotechnology development. Each provides a piece of the puzzle to understanding the materials most important to national defense; yet, there is no simple or perfect way to bundle strategic materials. Categorizing a material as either *strategic* or *critical* is difficult. Exacerbating the situation further, there is no standardized definition for categorizing a material. Multiple factors determine the nature of criticality including, but not limited to, material end-use, geography, geology, environment, economics, politics and geopolitics. Even after a material is categorized, its status is dynamic and intertwined with rapidly changing technologies. Changes in source availability, discovery of substitutes and the emergence of new applications may redefine the material's criticality.³

Over the past few years, numerous reports have defined *strategic* and *critical* minerals and materials. These include, but are not limited to, the 2008 DoD Strategic Materials Protection Board (SMPB) Report, 2008 National Research Council Committee on Critical Mineral Impacts, 2010 Critical Raw Materials for the European Union (EU) report, 2011 National Defense Authorization Act (NDAA) and the 2011 Department of Energy (DoE) Critical Materials Strategy. Appendix A provides the definitions from these reports; however, in determining criticality, the definitions in these reports generally apply some measure of a material's importance in use and its availability.⁴ In addition, these reports generally define a material (or mineral) as *strategic* or *critical* based on the roles and missions of the organization writing the report. For example, the DoE report defines a material as *critical* only if it is necessary for a "clean energy" effort.⁵ Similarly, the 2008 SMPB report very narrowly focused its definition of a material critical to national security by limiting the definition of a *critical* material to one "for which DoD dominates the market."⁶

For the purposes of this report, the definition of *strategic material* will refer to a non-fuel material that, per the FY2011 NDAA, is a material critical to national security:

- Upon which the production or sustainment of military equipment is dependent; and
- The secure supply of which could be restricted by actions or events outside US government control
- The term "military equipment" refers to equipment used directly by the armed forces to carry out military operations.
- The term "secure supply," with respect to a material, means the availability of a source or sources for the material, including the full supply chain for the material and components containing the material.⁷

"SWOT" Analysis

The following section identifies some of the strengths, weaknesses, opportunities and threats facing the strategic materials industry. As a nation, we have used the National Defense Stockpile (NDS) only a few times since the Korean War to meet US defense industry needs (note: the NDS concept is defined in more detail in Chapter 7 of this paper). The sparse use of the NDS indicates the agility and strength of the materials industry and highlights the resilience of the private sector in adjusting to shortages; it also emphasizes the increased sourcing opportunities the United States has enjoyed from globalization. The United States has seldom been unable to obtain the materials it needs when it needs them.

Growing US reliance on outside sources for almost every material used in the defense industrial base is both a strength and a weakness. The United States' strong interdependence with the global economy provides access to diverse suppliers and competitive prices for most materials. For certain key materials, such as Rare Earth Elements (REEs), international supplies have become more concentrated.

Outdated and complex laws and policies also seem to hamper the industry supporting the materials markets. For example, it takes approximately seven to ten years to secure multiple approvals from state and federal agencies to open a mine (i.e., obtain a mine permit) in the United States.⁸ Additionally, the barriers to entry for most small companies to compete are high (e.g., significant capital/investment and start-up costs are required, approximately \$1-2 billion).⁹

On the other hand, opportunities for collaboration across industry, government, academia and international alliances are substantial in this field. The country may reap large gains for national security if it develops these partnerships properly. Research and development (R&D) in the material field holds great promise as well. For example, innovations in the development of bulletproof vests, aircraft and tanks have dramatically changed the world and warfare.

Threats to the strategic materials industry are posed primarily by supply disruptions and limited availability of some natural resources. For instance, the rise of China's mining and materials processing capabilities may represent either a threat or an opportunity—depending on the emerging scenario and which lens one uses to view it.

Porter's Five Forces Model

A useful way to analyze the industry is through Michael Porter's Five Forces Model. This model reveals that barriers to new competition are substantial, especially on the mining side of the industry.¹⁰ With huge capital costs and very long lead-times to obtain permits, it is difficult to enter the mining business in the United States (or really any nation). The threat of substitutes for some high-priced materials is low in the short run, but significant in the long run as high market prices encourage R&D for other methods and similar materials. There are always tradeoffs, and many of these tradeoffs involve sacrificing the performance of products that use a substitute in lieu of a strategic material. Limited availability of many materials means the bargaining power of the customer is low, and the relative bargaining power of the supplier is high. For example, while ores containing REEs are relatively abundant, processing REEs produces significant pollution. Over the last decade, China has dominated REE production and currently produces 96% of the world's REEs. The United States is one of the world's largest REE consumers, but it possesses limited bargaining power. Most of the businesses in the materials industry differentiate themselves by the product produced or service provided. There is also significant

competitive rivalry in some parts of the industry (e.g., titanium manufacturing). Still, in other areas, some US firms operate with limited or no domestic competition (e.g., beryllium processing-monopoly; palladium mining-oligopoly).

According to Porter's model, the strategic materials industry is most attractive when barriers to entry are low, supplier and buyer power is low-to-medium and the availability of product substitutes is low. In an environment characterized by high rivalry, successful firms are best able to maintain profits and market position when barriers to entry (e.g., high capital investment costs to build infrastructure/capacity and obtain permits) block new competitors from entering the market. The authors found that firms can differentiate products by adding value along the supply chain, to include vertically integrating their operations, signing long-term supply agreements with end users, and developing new uses for a material. For example, one company the seminar visited instituted a mine-to-magnets business model to reduce market volatility and is developing its own commercial product that requires large quantities of the minerals it produces.

Additionally, companies hold an advantage if they can access cheap and reliable power and water supplies—key inputs in this capital intensive industry. Such an advantage helps companies control operating costs and can discourage other competitors from entering the field. These two factors contribute to "Supplier Power" and can drastically impact or limit "Rivalry Power" if left unmanaged. For instance, in Chile, the power required to mine and process copper was one of the most important factors in controlling a venture's operating costs. Viable copper processing operations depend greatly on access to affordable power and abundant water. During meetings with foreign government officials and industry leaders, the authors learned of a power agreement that had been negotiated between Chile and Argentina. When Argentina failed to deliver power as agreed, Chile faced an energy shortfall and quickly had to identify alternative sources and establish new contracts, a situation that negatively affected the profitability of Chile's mining sector in the short- and long-run. In the interim, copper production suffered as the prices of this key input escalated. Countries with adequate domestic sources of water and energy (e.g., natural gas, coal or hydroelectricity) and companies with firm long-term commitments for these inputs do not have to deal with such difficult production decisions. Power and water coupled with reliable access to raw materials become true competitive advantages over one's global rivals and must be carefully considered as long-term factors in the production decision-making process.

In the United States, a complex set of federal, state and local permitting and environmental regulations serves as a key barrier to entry in the mining sector. Chile and the Dominican Republic's more centralized national governments implement simpler regulatory processes that make it easier for companies to establish mining and refining operations. It is possible to open such operations in two to four years in Chile or the Dominican Republic, whereas it takes seven to ten years to do so in the United States. Both countries maintain solid safety, operational and environmental regulations and most companies also comply with regulations of the countries in which they are headquartered. The primary regulatory advantage some foreign countries have is a consolidated governance structure, relative to the United States, that lowers compliance costs. This streamlines processing and eliminates many of the inconsistencies (or contradictions) found within the overall US regulatory structure. The result is that new strategic material ventures are less likely to locate in the United States if comparable geologic or processing resources/infrastructure are available in other countries.

See Appendix B for an example of a Five Forces analysis applied at the operational business level.

CHAPTER III: CURRENT CONDITION OF THE INDUSTRY

Such a wide-ranging industry base involved in the development of strategic materials invites a closer look at the underlying trends and the status of the industry today. Looking at the past 32 years of research at ICAF unveils interesting trends and perspectives.

Review of ICAF Industry Reports for the Past 32 Years

Appendix C illustrates the last 32 years of reports accomplished by the ICAF Strategic Materials Industry Study. The first ICAF industry report was completed in 1980. In 1981, the first report with a specific focus on the topic of materials was published. Since then, terminology has evolved from "critical defense materials" to "advanced materials" and finally what is referred to today as "strategic materials". While many topics and issues appear very similar, there have been significant changes and an evolution of thought.

Trends & Status

The most striking change in the industry reports is the change from a Cold War mentality to the realization of an interdependent globalized economy. This change in world outlook has greatly influenced policy recommendations over the years. The rise of China as a major producer of minerals and rapidly growing global economic powerhouse also influenced the viewpoints and suggestions of different industry study reports. It was not until 1997 that the ICAF reports even discussed China. Looking at the USGS Mineral Commodity Summary indicating the US net import reliance for selected non-fuel mineral materials from 1979, China was not even listed on the major import sources. In comparison, in 2011, China was listed as a major supplier for 30 of the 67 minerals listed and 11 out of the 19 minerals that the United States exclusively relies on today (see Appendix D). China's gradual elevation to prominence in this field is not surprising, as the entire strategic materials supply chain has been affected by the gradual shift to a more interdependent and global economy, giant multinational companies and a shift from Cold War thinking to a more multi-polar world.

In the 1990s and 2000s, with no real peer or peer threat, the risk of supply disruptions in strategic materials was substantially less than in the previous era. Major advances in technology and materials discussed in the ICAF reports include: nanotechnology, micro-electromechanical systems (MEMS), composites and ceramics. Many of these advances changed the dynamics of US reliance on outside sources. The Boeing 787, for example, is comprised of 50% composite material and only 20% aluminum; it has 50 suppliers, many located outside the US, that produce key parts of the aircraft.¹¹

Some enduring ICAF research topics include: the NDS, science and technology education, need for R&D and environmental concerns. The topic of stockpiling is one of the more prevalent and most controversial of all the enduring topics. Out of the 32 years of available industry reports, 7 did not publish a report or the subject of strategic materials was not an ICAF industry study. Of the 21 reports that discussed the stockpile, 10 recommended stockpiling and/or increasing the NDS (these reports were primarily from the early 1980s and 1990s). Seven of the reports suggested downsizing the stockpile and eight made no recommendation either way. Many of the issues in industry today have endured and evolved over the past 32 years. Understanding them helps identify where the United States is and shape a better way ahead.

CHAPTER IV: CHALLENGES

Evaluating the current conditions and industry trends allows us to appreciate the full spectrum of challenges facing the industry. As stated, recognition of the interconnectedness of the nation's minerals to national defense is vital to shaping the policies, regulations and laws affecting US strategic materials today. Even though the strategic importance and value of mineral resources is well recognized, the US government often struggles with implementing clear, deliberate and cohesive policies to regulate its natural resources and industrial mining sector most effectively. Current US policy regarding strategic materials is frequently difficult to analyze, understand and implement. The myriad laws, regulations and reports create a fragmented and near incomprehensible framework for developing a coherent policy and strategy.

As globalization moves world economies from independence to interdependence, a new strategy to ensure the availability and access to strategic materials is necessary. Redefining the way required materials are resourced has changed, and the decision making process must recognize these changes. A more targeted approach to sourcing critical materials should capitalize on today's dynamic processes and opportunities. A good starting point is to redefine how one thinks about the NDS and create more "tailorable" approaches to the sourcing of strategic materials.

There are also questions about whether the US government is best equipped to respond to material shortages or whether input from commodity dealers, who have an intimate understanding of global material markets, might better inform US strategic materials policy. Each individual material demands a specific solution and overarching "families" of policy to support the national security goal of unimpeded availability of strategic materials, particularly contingency planning for short- and mid-term emergencies. For high-priced and variable commodities like platinum, the maintenance of a physical buffer stock can cushion short-term defense demands against supply interruptions or significant market fluctuations, while recognizing that domestic supplies and adjustments may later react during longer-term situations. For materials where defense is proportionally a minor market player, such as REEs, a contingency contract approach may be more feasible.

The challenge for the US Executive Branch is to balance new more flexible options and approaches with antiquated legislation. It must also ensure future decision-making considers affordability, efficiency and reliability when measured against national security outcomes.

Another complication is how best to implement efforts that streamline environmental permitting processes, reduce bureaucratic overlap and improve environmental oversight and enforcement while simultaneously incentivizing a strong domestic investment climate for mining and mineral production. Finally, standardizing definitions for *strategic* and *critical* materials would prove beneficial.

CHAPTER V: OUTLOOK

This section assesses the future health of the strategic materials industry and introduces an evolutionary concept for consideration. As noted, the industry as a whole is awkwardly defined and complicated. However, while the strategic materials industry does not fit neatly into an analyst's categories, there are some notable similarities. The majority of US firms studied and visited—regardless of where they fit in the value chain from exploration-to-end product—all produce multiple products or provide multiple services. These companies invest in R&D and recognize the value of investment over the long run. During this period of low interest rates,

they have found it cheaper to borrow money and invest more in production and capital infrastructure. They tout the value of supply chain integration and have considered—or already adopted—horizontal or vertical expansion as well as international joint ventures to leverage the benefits of integration. Finally, they all appear to be growing industries dedicated to staying in business for the long haul, differentiating their products and services, providing customer and shareholder value and participating in the international competitive markets to meet the demands of global customers.

Strategic Materials...Evolution of the Concept

The concept of *strategic materials* is not new. While the vernacular has changed and matured, the theoretical idea rests with the premise that some materials are more important than others and, thus, require special attention. This principle has been a part of the public dialogue for well over a century. The most notable and enduring piece of relevant legislation was the Buy American Act of 1933. This legislation was intended to protect domestic labor by mandating "domestic preference" procurements for all government-funded acquisitions, unless a specific exemption applied.¹² It is the phrase, "unless an exemption applies" that unintentionally created the concept of strategic materials. Throughout the years as lawmakers sought to protect the US industrial base, successive legislation (e.g., the Berry Amendment and Buy American Act) narrowed the criteria for exemptions. Together, the body of domestic source restriction legislation gave rise to special categories or lists of materials (e.g., specialty metals; defense items) that specifically required attention and "protection."

At the heart of domestic source mandates lies a debate between free market proponents on one side and protectionists on the other. Starting with the Berry Amendment in 1941, national defense became inextricably mired in the debate. The conversation was no longer about pure economic principles, but rather about ensuring American security and hegemony in the world. Going forward, social and political interests prevailed over economic ones. Since the eve of World War II, when the United States enacted the Berry Amendment, the US industrial base was essentially bifurcated into defense and non-defense. The defense industrial base would be protected so that, in times of adversity or war, access to strategic materials would be guaranteed. The list of materials protected under the Berry Amendment includes food, clothing, fabrics (including ballistic fibers), specialty metals, stainless steel and hand or measuring tools.¹³ Since 1941, any major discussion that attempts to reduce protectionist legislation, particularly in the defense arena, is met with questions such as, "...If the US becomes dependent on purchasing equipment and supplies from foreign sources, what prevents an adversary from cutting off US access to such items or refusing to build militarily critical items in times of crisis or conflict?"¹⁴

Regardless of the rhetoric, the prevailing sentiment has been to identify special materials, deem them as *critical* to national defense, label them accordingly and protect the domestic base that produces them. Cost effectiveness, best value or best products are still part of the conversation. However, the growing proclivity to obscure politically-driven agendas under the "critical to national defense" label has expanded to the extent that almost any special material could qualify.

It is not unusual for the NDAA to modify the procurement of strategic materials every year. One of the more notable recent changes was the FY2007 NDA (Public Law 109-364), which moved the specialty metal provision from the Berry Amendment (Title 10 USC 2533a) into a separate section of Title 10 (10 USC 2533b) and Section 843 of the same Act that required the creation of a SMPB.¹⁵ The following year, in the FY2008 NDAA, Section 803, the SMPB was given

broader direction to, "perform an assessment of the viability of domestic producers of strategic materials, the purpose of which is to assess which domestic producers are investing, or plan to invest on a sustained basis, in the development of a continued domestic production capability of strategic materials to meet national defense requirements."¹⁶

By its second annual meeting, the SMPB made two audacious achievements. First, it initiated a parsing out of the term *strategic* from *critical* in the defense procurement discourse. Second, it reported to Congress that specialty metals, as defined in 10 USC 2533b, are not "materials critical to national security" for which only a US source should be used. It remains to be seen if this indicates an appetite to reduce or increase the government's role in the country's industrial base. Whereas defining the outlook of the industry is key, it is equally important is to understand the evolving roles and objectives of the US government. The authors deliberate this more closely in the following chapter.

CHAPTER VI: GOVERNMENT GOALS AND ROLES

This section discusses what the goals and role of the US government should be vis-à-vis the strategic materials industry. Over time, the US government enacted various laws, regulations and policies that affect strategic materials. Some of these laws broadly apply to the entire market while others focus quite specifically on certain areas. These laws, regulations and policies were designed primarily to protect domestic sources, maintain US competitiveness and ensure environmental standards. As well, all of these statutes affect the efficiency of the strategic material industry. Below is a brief description of the major laws, regulations and policies relevant to strategic materials. In general, choosing to interfere with the competitive market entails significant risk by introducing dead weight loss into the system and decreasing US competitiveness. Even if done with the best of intentions, government intervention may lead to negative unintended consequences (i.e., unknown second- and third-order effects).

As the leading world economy after World War II, with fifty percent of global production, the United States produced all the materials deemed *strategic* and *critical* for the nation. Over time, as other nation's economies recovered and grew, the forces of the competitive market and globalization resulted in the loss of US domestic productive capacity of certain key materials. Government action should align policy and regulations with US strategic interests in support of economic and national security. The greatest drawback of government action is its inability to respond quickly to a dynamic global economy. Laws written decades ago drive today's actions. The government's role should be to promote and allow "natural" market forces to balance industrial capabilities and intervene if national security is determined to be at-risk. Ultimately, the US government has a legitimate interest in ensuring the availability of some strategic materials to support domestic US defense production needs and secure susceptible supply chains. The following subsections describe each government measure and its intended purpose.

National Defense Stockpile (NDS)

After WWI, it was clear the US government needed a way to eliminate or reduce, "a dangerous and costly dependence by the United States upon foreign sources for supplies in times of national emergency."¹⁷ The history of the NDS dates back to the time of World War II. The enabling legislation was included in the Critical Materials Stock Piling Act of 1946, which was an amendment to the Strategic Materials Act of 1939.¹⁸ It gave the Secretaries of War, Navy and Interior in conjunction with the Secretaries of State, Treasury, Agriculture and Commerce, the ability to authorize and determine which materials are *strategic* or *critical*, defining the specific

amount and quality of materials to be stockpiled.¹⁹ The 1965 Materials Reserve and Stockpile Act combined previous separate efforts into the National Stockpile.^{20,21} The 1979 Strategic and Critical Materials Stockpiling Revision Act created today's NDS and transferred it to the Federal Emergency Management Agency (FEMA).²² A 1988 executive order moved control to the Secretary of Defense (SecDef) with management activities delegated to the Defense Logistics Agency.²³ For the last 66 years, the US has maintained stockpiles of materials it deemed *strategic* and/or *critical*. While the NDS has reduced its inventory over the past decade, it still contains some strategic materials for defense purposes.²⁴

The Berry Amendment

In 1941, Congress placed domestic source restrictions in the Defense Appropriations Act. Now known as the Berry Amendment, the act requires that DoD buy certain articles, mainly food, clothing and fabrics (among other requirements) from domestic sources.²⁵ The 2007 National Defense Authorization Act (NDAA) moved the specialty metal clause from the Berry Amendment to a new legislative provision (10 USC Section 2533b).²⁶ There are also seven new provisions in various stages of Congressional action that may affect the Berry Amendment.²⁷

Specialty Metals Clause

As mentioned, the specialty metals clause is now in its own statute.²⁸ The statute requires that DoD use domestic specialty metals sources for end items or components of end items. The statute lists specific details on the type and composition of metals considered "specialty," and details specific exceptions, reciprocal clauses and waiver procedures.²⁹ Another issue concerning specialty metals is the 2007 NDAA requirement directing the SecDef to create a Strategic Materials Protection Board (SMPB). The SMPB is required to determine what items should be designated as critical to national security, and to recommend changes for future domestic source restrictions.³⁰ Finally, the 2008 NDAA refines the duties of the SMPB and provides more flexibility regarding using domestic sources for specialty metals.³¹

Strategic Materials Protection Board (SMPB)

As directed in the 2007 NDAA, the SecDef established the SMPB to assess the need for and risk to materials supplies and to develop a strategy for ensuring secure supplies.³² The SMPB published a report in 2008 identifying high purity beryllium as a strategic and critical material.³³ Accordingly, DoD used DPA Title III authorities to contract with the company Brush-Wellman (renamed Materion) to build and operate a high-quality beryllium plant.³⁴ Finally, to refocus the SMPB, the 2011 NDAA redefined *strategic* and *critical* materials and directed DoD to publish a report no less than every two years.³⁵ The DoD has not yet produced another report.

The Buy American Act

The Buy American Act, passed in 1933 and amended four times since, is a method to protect US labor. The act requires that federal agencies use domestic sources for products acquired for public use.³⁶ Products must be manufactured in the United States and contain 50% domestic source. A currently proposed Senate bill would amend the BAA to change the domestic content requirement from 50 to 75%.^{37,38} While the BAA is the key federal procurement control act, its requirements may be superseded by other legislation or international agreements, such as the North American Free Trade Agreement (NAFTA) if the BAA contradicts the agreement.³⁹

The Defense Production Act (DPA)

The NDS and the DPA have been the US hedge against the possibility of adversaries restricting US access to critical minerals, such as REEs. The enactment of the "Defense Production Act of 1950, as amended, confers upon the President [the] authority to force private industry to give priority to defense and homeland security contracts and to allocate the resources needed."⁴⁰

The DPA gives the President authority to force private industry to support national defense needs. Established in 1950 with seven titles, it now contains only three active titles. Title I grants the authority to demand priority for materials, resources or production capacity for defense-related products. Title III grants authority to provide incentives to develop, modernize and expand defense productive capacity.⁴¹ Title VII supports numerous activities, such as review of mergers for national security impacts or flagging commercial carriers for defense purposes.⁴² DPA authorities are not permanent and must be periodically reauthorized. Authorization of the current DPA, Public Law 111-67, ends on September 30, 2014.⁴³

Environmental Provisions

Domestic environmental laws also affect the strategic material industry. Environmental laws such as the 1969 National Environmental Policy Act (NEPA), 1977 Surface Mining Control and Reclamation Act (SMCRA), Clean Air and Water Act and Toxic Substance Control Act affect the ability of commercial business to operate mines and, hence, mineral production in the United States. These laws regulate domestic mine operations and enforce compliance with environmental standards. The majority of industry officials consulted through this research state that compliance with environmental laws is not a significant operational limitation. However, they contend the lengthy initial environmental permitting and approval process is a detriment to establishing new mines in the nation. On average, industry officials maintain that the fractured, burdensome, time-consuming and inconsistent nature of the permitting process (often controlled by individual states and not federal officials) places US operations at a competitive disadvantage.

Other Provisions

The strategic material market is global. As such, bilateral and multilateral international trade agreements, tariffs and duties change the nature of the strategic materials market and increase competition for these materials. These factors improve or degrade the competitiveness of firms in the strategic material industry. In some cases, international trade agreements take precedence over the Buy American Act or Berry Amendment, adding another layer of complexity for industry. Actions taken by the World Trade Organization (WTO) may also affect the strategic material market. The WTO provides mechanisms that member nations can use to identify unfair trade practices or seek remedies. At the same time, the WTO, successor to the post-WW II General Agreement on Tariffs and Trade (GATT) provides trade rule exemptions to member states for national security purposes. Recently, the United States, EU and Japan filed a WTO action against China that argued China's REE export quotas unfairly favor Chinese industry. A WTO decision could influence Chinese policy and the broader strategic material market.

Finally, US export controls also affect the strategic material market. Presently, the United States does not have any export restrictions on minerals. However, export quotas, taxes, duties and charges may be used to affect the industry. Current US export controls rely on the International Traffic in Arms Regulations (ITAR) and Export Administration Regulations.⁴⁴ These laws govern the export of both defense-related and commercial products.

CHAPTER VII: ESSAYS ON MAJOR ISSUES

The following essays further the discourse on the importance of strategic materials to national security. These topics include: the National Defense Stockpile; risk mitigation strategy; US environmental regulations; supply chain management; recycling; emerging technological advances; and networks among US government, industry, academia and international partners. Additionally, this section offers potential ways to mitigate economic and national security risks.

National Defense Stockpile (NDS)

After World War I, Bernard Baruch reported to the US War Industries Board that production efforts were seriously impeded by shortages of imported strategic materials.⁴⁵ He recommended that the United States begin stockpiling strategic materials. This led to the development of today's method of ensured access to key minerals—the Defense Logistics Agency Strategic Materials (DLASM), also known as the NDS. Resources held in the stockpile have changed throughout the years, with the national plan being to store *strategic* or *critical* materials for availability when needed. However, current processes are cumbersome and the NDS is slow to react to emerging requirements or innovations that affect material demands and/or availability.

As globalization moves world economies from independence to interdependence, a new strategy to ensure the availability and access to strategic materials is needed. Moreover, analysis of the last 32 years of ICAF research suggests that the stockpile should be more proactively managed and incorporate dynamic processes better tailored to individual material markets versus the current "one size fits every material" approach. Cost alone requires a new method to ensure continued access to strategic materials. The NDS holds \$1.3 billion in inventory with most of the stock deemed "excess material" and in the process of being sold off.⁴⁶ Present value is down from its 1981 value of \$14 billion (approx \$38.5 billion in 2012 dollars).^{47,48} In 1995, the stockpile held 90 commodities at 85 different locations. Today, it holds 20 commodities in 10 locations.^{49,50} Maintenance cost for the stockpile in 1989 ranged from \$667M to \$1.4B in 2012 dollars.^{51,52} Starting in 1992, Congress clarified the stockpile's intended use, changed the amount and type of materials needed and began selling excess stockpile materials. The use of the NDS from Section 2 of the Strategic and Critical Materials Stockpiling Act, as amended by the 1993 NDAA, stated that "the NDS shall serve the interest of national defense only and not function for economic or budgetary purposes."⁵³ This highlights another reason to consider shrinking the stockpile and managing particular materials based on their market characteristics.

Managers of the stockpile also contend with antiquated laws regarding the NDS. Each planned acquisition of material must be put into the Annual Materials Plan, which is submitted to Congress by February 15 each year. This plan contains materials the NDS manager plans to purchase in the next four years.⁵⁴ The President and Congress can release material from NDS, but only under the following conditions: 1) release by the President (non-delegable); 2) declared national emergency; 3) legislative authority following material deemed to exceed DoD needs; and 4) special statutory authority when material is not deemed in excess.⁵⁵ This extremely inflexible portion of the law makes using the NDS to support defense contractors very challenging. Another issue is that revenue from sales of material goes into a general fund. These funds can be used for discretionary spending by Congress, leading to what some have labeled wasteful "pork" spending. Another concern is that NDS sales have direct impacts on broader markets for many materials. Broadcasting years out what the government plans to buy and sell

in a commodities market with limited numbers of participants can impact market dynamics in ways that disadvantage the nation and its taxpayers.

Managing the NDS in this way results in inefficiency. Moreover, management of diverse materials—each with differing applications, domestic production/availability and worldwide market conditions—highlights that neither one overarching approach nor a traditional physical stockpile can address every challenge efficiently or economically. Each individual material demands a specific solution and overarching "families" of policy to effectively maintain supply and meet short- and mid-term emergencies. For high-priced and variable commodities like platinum, maintenance of a physical buffer stock can cushion short-term defense demands against supply interruptions or significant market fluctuations, while recognizing that domestic supplies and adjustments may later react during longer-term situations. For more limited items where defense is a minor market player (proportionally), such as REEs, a contingency contract approach may be more feasible. For example, contracting with Australian miners for ore to supply US refining needs may more quickly meet defense requirements, with added security based on close alliance ties.

Some progress has been made to improve the NDS. To address concerns in 2006, Congress directed DoD to determine whether the NDS should be reconfigured to adapt to current market conditions.⁵⁶ This directive prompted the National Material Advisory Board to meet in 2007. In the 2008 NDAA, Congress again tasked DoD to examine the NDS, which led to a December 2008 SMPB meeting. Both boards recommended reforming the NDS. The SMPB suggested the NDS be transformed in the Strategic Material Security Program (SMSP). The SMPB suggested that "reliable access does not always necessitate a domestic source," and that DoD "sometimes may be dependent on reliable non-US suppliers."⁵⁷ While this view goes against the general concept of the Stockpiling Act—to preclude US reliance on foreign sources—it leverages the global economy, which was not as interdependent in 1939 when the Act was signed.

Using this background, four options for improving strategic materials availability were analyzed:

#1: Status quo/deplete the stockpile: This option depletes the NDS in a matter of years and continues with the inefficient and outdated policies. In the event of a national emergency, Title III of the Defense Production Act may be used to procure critical material available domestically.

#2 Implement SMSP: "We need a strategic reserve, not a stockpile."⁵⁸ Configure the NDS into the SMSP and modify the Stockpiling Act to grant SMSP programmatic flexibility to acquire the right material and ensure essential materials are available to respond to current and upcoming threats. Availability may be tailored by material, range from small buffer stocks to contract vehicles and, in a very few cases, maintain a traditional "stockpile" to meet the needs of an envisioned prolonged scenario.

#3 Outsource the NDS: Establish a contract to provide required materials at the required time, similar to a "call option" on a commodity. Requires the NDS manager to properly identify needed commodities and auditors to check periodically on the ability of the contractor to deliver. US government does not store material and could roll the current cost of maintaining the NDS into funding the contract.

#4 Establish a strategic materials "center of excellence (COE)" or networking forum to augment the SMSP. Academia, industry, DoD and international partners need a coordination venue.⁵⁹ A networking forum or COE provides a venue for information-sharing, continuity, knowledge management (KM) and policy review.^{60,61,62} KM division compiles comprehensive knowledge base, coordinates university research, oversees public/private development efforts and shares best practices to promote rapid advancement of ideas.⁶³ Policy division also serves as a resource for Congress to reference when making policy decisions that affect national and international interests.

Similar to previous industry studies, the authors identified a need for a central coordination body for the materials sector. The concept of a COE for strategic materials provides an important step in the evolution of strategic materials resourcing and decision-making. Networking supplies valuable interface for industry, academia, government, other stakeholders and international partners and allows members to share information regarding necessary reforms. Of the options presented, the authors contend this approach offers the most flexibility, while it mitigates national security risk most effectively. Redefining how the United States resources to accommodate a more demand-driven, market-based methodology in collaboration with allies and industry provides the depth and breadth of experience needed to accurately and consistently source materials critical for national security.

Risk Mitigation Strategy

Availability, consistency and reliability help to improve US strategic materials management and facilitate the sourcing of required materials in peacetime and wartime. However, merely identifying a material as *strategic* or *critical* does not provide the scope of vulnerability or granularity of information necessary to assess and mitigate the associated risks. Authorities charged with strategic material responsibilities should also incorporate risk management techniques into their analyses to provide greater fidelity of the mineral's vulnerability. With this type of assessment, government and industry alike can better scope the extent of mitigation actions, including strategy, resourcing, legislative and investment decisions.

A standard risk management tool analyzes risk by determining the *likelihood* of an event and the *consequence* of that event occurring. This is plotted in a two dimensional grid with *likelihood* increasing on the vertical axis and *consequence* on the horizontal axis. The Committee on Critical Mineral Impacts on the US Economy took this approach in their analysis of minerals. In this model, *consequence* represents impact of supply restriction measured in higher cost or unavailability of the resource; and *likelihood* characterizes supply risk reflecting supplier concentration, market size and import dependence.⁶⁴ To develop this approach further, the authors propose an assessment of each material market based on expanded criteria.

As a result, consequence analysis should address cost impact and availability through a wider "threat" perspective. For instance, using the committee's criteria, a material such as platinum is assessed in the upper right of the risk matrix suggests high criticality because of unstable sources. However, when viewed through a more expansive threat lens, supply interruptions would not lead to a national existential, sovereign or significant economic crisis. This assessment informs decisions on the extent of vulnerability mitigation efforts and may include prioritization of demand; reliance on recycling or temporary policy adjustment (e.g., relief from an environmental regulation) while sourcing is resolved. This type of analysis suggests that although materials are *subject to supply restrictions* and *essential in use* in the context of current demand, they may not be *critical* with a change of the underlying conditions, such as regulatory adjustment. In this case, national resources may be more productive if applied elsewhere.

Furthermore, *likelihood* analyses should guard against considering "import dependence" in isolation. Reliance on foreign suppliers may be a positive economic condition if the sources with the greatest comparative advantage are supplying products leading to market efficiency, particularly if the exporters are reliable US allies. To determine if import dependence creates a significant supply risk, authorities should assess dependence in concert with supplier

concentration and market size—as the committee did—and include an analysis of plausible supplier actions in this highly interdependent global economy.

One final consideration to make mineral risk management assessments more robust is the concept of *velocity* (i.e., the speed in which a risk may come to fruition). This may be represented in a third dimension of the risk matrix or as an additional color code assigned in the standard two axis risk tool. Since securing new mineral supply sources can take months to years, the speed that a mineral supply is exhausted and a supply risk is realized is very relevant. *Velocity* takes into account other probability factors and demands for critical requirements against material in the supply chain, stocks on hand and availability or amount of material for recycling. An analysis of a mineral's *velocity* would be useful in determining mitigation steps. For example, if a certain strategic or critical mineral's *velocity*, *consequence* and *likelihood* are all high, then it may be an ideal candidate for protection measures (e.g., initial stockpiling) and subsequent initiatives to secure a domestic supplier (e.g., DPA Title III).

In the end, US government strategy for strategic material vulnerability should determine the most effective and efficient use of national revenue; determine the best policy to avoid compromise of national security interests; and consider applying countervailing forces to existing negative externalities without contributing to new ones. Moreover, the government should partner with industry and further develop mineral assessments using the criticality matrix to incorporate risk management methodologies and information from other assessments, such as the European Commission study. These information-sharing efforts help to enhance policy options, reduce uncertainty, improve data collection, accelerate assessment updates, refresh material lists and shorten lead-times—all essential mitigating actions to lessen the risk to national security.

In addition to implementing strategies for mineral assessments, risk mitigation and data collection efforts may also help improve the policy and decision-making process, specifically when balancing environmental issues against other national priorities.

Environmental Regulations

The Fraser Institute has published annual results of a survey of metal mining and exploration companies since 1997.⁶⁵ Only two of 14 US states that were identified in the most recent survey made the "Top 20" as measured by the Policy Potential Index (PPI).⁶⁶ The PPI "is a composite index that measures the climate for exploration created by government policies, including taxation, environmental regulations, duplication and administration of regulations, native land claims, protected areas, infrastructure, labor and socio-economic agreements."⁶⁷ The remaining 12 US states hold rankings between 21st and 51st, out of 93 total jurisdictions examined.⁶⁸ Some of the reasons for these low rankings rest with the professed complexity and multitude of US land use, environmental and occupational laws and regulations required before mining companies can actually explore or exploit mineral resources. Appendix E depicts a list of federal laws that impact mining and mineral production.

The magnitude of paperwork and perceived bureaucracy makes opening new mines costly and time consuming. It also inhibits investor interest in expanding the sector. Completing required permitting to begin operations takes seven to ten years, on average, in the United States compared to less than two years in Australia.⁶⁹ The increasing costs (time and money) to comply with environmental regulations, along with uncertainty over future restrictions, have made US mining and mineral production relatively unattractive compared to other investment opportunities. The National Mining Association (NMA)—a US mining industry lobbying

organization—has calculated that the US share of global investment spending in metals mining declined from 21% in 1993 to just 8% in 2010.⁷⁰ The NMA also notes that US dependency on foreign mineral imports is clear (e.g., 100% import dependence for 18 mineral commodities).⁷¹

Consistent with our Federalist system, mining in the United States is governed by a myriad of federal, state and local laws and government agencies. As noted, the United States does not have a comprehensive, integrated policy on access to critical minerals and materials.⁷² For example, different federal mining laws and compliance standards apply depending whether mining occurs in private lands or public domains. Governance of the latter varies further according to the agency responsible and the status of the public land in question (e.g., some land is "withdrawn" from mining use).⁷³ The primary federal mining law that continues to govern much of the mining exploration and development in the United States is the *General Mining Law of 1872*.⁷⁴

The *Mining Law* regulates mining on federal public lands, where approximately 216 million acres of federal land, representing one of every eleven acres in the United States, are open to mining.⁷⁵ While the *1872 Mining Law* contained no direct environmental controls, environmental awareness in the 1960s and 1970s spawned a body of laws that now impact all mining (e.g., patented land, leased-land operations and private land holdings). Environmental groups argue that the *1872 Mining Law* is obsolete and additional comprehensive environmental regulation of mining is needed. In contrast, the NMA contends that existing environmental safeguards are more than adequate.⁷⁶ The NMA notes that three dozen federal environmental laws and regulations cover all aspects of mining.⁷⁷ Many of these federal laws suggest potential redundancy and each state has laws and regulations that mining companies must follow as well.

The mix of federal, state and local laws inhibit US mining development and effectiveness of fiscal enforcement resources as agencies spend limited funds to train and deploy personnel doing similar work.⁷⁸ Any effort to streamline and shorten the permitting process or reduce the bureaucratic overlap may free up fiscal resources to improve actual environmental oversight and enforcement while enhancing the domestic investment climate for new mining and mineral production. Greater development of US mineral resources may also reduce reliance on foreign sources, create new jobs, and perhaps encourage return of downstream manufacturing closer to the "upstream" supply chain.

To best alleviate the risks to national security brought on by supply disruptions, the United States should execute policies that help to ensure a steady, reliable and cost-effective supply chain for its strategic materials.

Supply Chain Management (SCM)

The concept of SCM, while intuitively simple in execution, is both complex and difficult. Least among the reasons is a nebulousness regarding the definition of what constitutes a supply chain and what functions are encompassed within supply chain management. There is no commonly accepted SCM definition within or between the DoD and commercial sectors. This disparity creates confusion about when the supply chain starts and stops. Is the supply chain from mineral origin to final consumption or is it more limited from material procurement to original customer delivery? In the national security sector, there appears to be a predilection in the supply chain management discourse for the latter; which infers the supply chain starts with material production, versus mineral acquisition, and continues through end-item delivery. However, the consensus is far from solid.

The need for clarity on this issue of, "*What is a supply chain?*" is beyond mere semantics. Defining at what point government is, or should be, responsible for securing the "full supply chain" for strategic material is a national imperative. How much, if any, US government intervention is required in the free market for strategic materials guides decision-making and influences risk mitigation strategy and resource expenditure. The position the nation takes on this issue is beyond the simple value chain framework, it underlies it. The supply chain is not a discrete set of functions; rather, it is a philosophy about interconnected functions and processes to fulfill (e.g., source) requirements and lay out activity responsibilities.

The lack of consensus on what constitutes the supply chain and who is responsible for it is not the only issue. Another issue is the imbalance the US government appears to place on the front end (e.g., acquiring end) of life cycle management for strategic materials. The emphasis is currently on providing new material for new requirements. This may be linked to the etymology of supply chain management. That is to say, how the concept of "supplying" the requirement evolved as a management discipline.

Following the recent attention REEs have received in the media, the myopia that seemed to prevail in the strategic materials conversation appears to be correcting somewhat. Under an expanding recognition that as global competition for strategic materials increases, a secure supply may be better based on a "sustainable materials lifecycle management" approach rather than focusing on the "acquiring end" of the supply chain. If this trend continues, the strategic materials conversation may expand the perception that new material is the only strategic material. The analysis of what really is *strategic* material in the national security discussion should facilitate a more comprehensive view of national security. The assessment and management of *strategic* and/or *critical* materials should consider risks at all life cycle stages. Reducing, reusing and recycling should become less altruistic activities of a wealthy nation and more of a national strategy to ensure material availability and threat reduction.

Reduce, Reuse and Recycle (3R)

High costs associated with mining and material production have incentivized corporations to explore technological solutions to gain economic efficiencies. Growing US reliance on the global market for many of these materials makes it all the more important that US corporations continually search for economic and production efficiencies to retain competitiveness. Three promising areas include reducing the amount of material needed in production, reusing or selling by-products of production and pre- and post-consumer waste recycling—also called the 3Rs.

Economic efficiencies in the production of the 47 strategic and one strategic/critical material identified by the Defense Logistics Agency (DLA) could be realized by using nanotechnology.⁷⁹ For example, neodymium, an REE and strategic material for which DLA is exploring risk mitigation strategies⁸⁰ provides a rich area for continued focus. Like most REEs, neodymium is a high cost material currently indispensable to numerous high-tech and military applications. Nanotechnology is an inviting strategy to reduce the amount of neodymium required during manufacturing of these high tech applications. Given the importance of this material, a collaborative environment (respecting intellectual property rights) among industry, academia and government may accelerate bringing technology from the laboratory into the market place. One example, Near Net Shaping (NNS), allows the reduction of needed production materials and reaps savings by producing complex geometries and parts closer to the desired shape and

tolerance of the final product. NNS also maximizes material, decreases production time and saves energy by reducing the number of manufacturing stages.⁸¹

In addition, REEs provide an appealing case for cost savings realized by reusing and recycling material. Where once the United States was the undisputed global leader in all stages of REE production, such production shifted almost entirely to China by 2002. As noted, this shift was partly a result of China's rapid economic growth, lower labor costs and fewer environmental standards. Fluctuating global demand and supply of REEs make it essential for the United States to develop alternate sources, including indigenous recovery and recycling capability.⁸² Considering that REE current end-of-life recycling occurs at a rate of less than 1%, investing in domestic recycling of REEs could significantly and positively affect the global market and benefit US production. Primarily, recycling minimizes the waste of scarce resources. Boosting the global supply of REEs may reduce the criticality of these key minerals, mitigate volatility of market prices and diminish reliance on foreign resources.⁸³ Several measures should be considered after weighing the implementation costs against the expected benefits:

- 1) Develop an overarching Federal-level e-waste regulation to standardize recycling compliance.
- 2) Commence a national recycling campaign for REE retrieval and reuse.
- 3) Encourage industry to design devices for easier REE removal upon reaching their end-of-life.
- 4) Create a competitive forum to encourage electronic recycling and reduce e-waste in landfills.
- 5) Create a temporary storage holding site for hazardous materials (HAZMATS), Light Emitting Diodes (LEDs) and magnets containing REEs until recycling technology becomes available.⁸⁴
- 6) Partner with the international community in environmentally compliant REE recycling.
- 7) Incentivize long-term investing in recycling plants and technology.

To encourage 3R practices, the United States should also consider removing barriers and crafting policies that support these efforts. Promoting growth of a vibrant domestic recycling industry, advancing nanotechnology to reduce material requirements, finding substitutes and developing collaborative partnerships can leverage limited US resources and instill more intellectual vigor in technology-based approaches.

Emerging Technology and Other Strategic Material Advances

In addition to 3R approaches, other technological advances throughout all sectors of strategic materials are emerging. This section briefly addresses nanomaterials, opportunities in the Arctic Ocean and undersea mining. Nanomaterial applications exist in nearly every commercial market, including clothes, food, computers, optics, energy, medical, automotive, aerospace and national defense. Given the wide range of dual use applications and importance of nanomaterials as an emerging technology to the global market, the implications on future economic potential and US national security are significant. Likewise, as land-based minerals become harder to extract and prices increase, undersea mining becomes a more viable and attractive method to extract these important minerals. Finally, as the Arctic Ocean becomes more accessible, opportunities to identify and extract seabed minerals may also be realized.

Based on R&D spending and estimated economic output, the United States leads the world in nanotechnology.⁸⁵ A 2011 "*Global Funding of Nanotechnologies & Its Impact*" study by technology analyst Cientifica provides insight into the country's nanotechnology competitiveness. The report suggests that the United States is the global leader in nanotechnology because of its funding and "combination of academic excellence, technology hungry companies, skilled workforce and availability of early stage capital, which ensures

effective technology transfer."⁸⁶ In 2009, over 1,000 US organizations competed in the nanotechnology global market for goods; this number was predicted to grow from \$147 billion in 2007 to \$3.1 trillion in 2015.⁸⁷ Given these substantial investments, it is reasonable to conclude the private sector sees great potential in the nanotechnology field. Therefore, the United States should continue to encourage nanotechnology investment to maintain its competitive advantage. Today, regulation is unable to keep pace with the rapid speed of nanotechnology developments. Within the federal government, numerous agencies are responsible for policy. However, the effort to regulate nanotechnology with policy has not been coordinated. This lack of coordination creates a prospective policy gap. Recognizing the potential for policy gaps in the nanotechnology field, the Executive Office of the President published a memorandum for the heads of executive departments and agencies in June 2011. Although the "Policy Principles for the US Decision-Making Concerning Regulation and Oversight of Applications of Nanotechnology and Nanomaterials"⁸⁸ does not establish policy, it does recognize a policy gap and provide guidance for agencies responsible for developing policy.

Along with nanotechnology, the Arctic Ocean offers a promising frontier for emerging technology. Global climate changes tend to be amplified in the Arctic Ocean. As worldwide temperatures increase, polar ice caps melt; this causes temperature in the polar region to increase more rapidly as ice caps melt.⁸⁹ As these ice caps retreat in the Arctic Ocean, the potential source for natural resources (e.g., oil, gas, minerals and fisheries) grows. To obtain access to a portion of these resources, the United States should ratify the United Nations Convention on Law of the Sea (UNCLOS) and submit the required paperwork to extend its Exclusive Economic Zone (EEZ) in the Arctic Ocean as soon as practicable. The United States is part of the Arctic Council that comprises countries bordering the Arctic Ocean having significant interest in Arctic region development. As the Arctic Ocean becomes more accessible, the Arctic Council should address international issues in the Arctic region. Current US policy in the Arctic is set forth by NSPD 66/HSPD 25. Overall priorities in this document that relate to seafloor minerals include supporting the Arctic Council's goal to develop the Arctic safely and responsibly while protecting the Arctic environment.⁹⁰ It also urges the US Senate to ratify the UNCLOS "to protect and advance US interests, including with respect to the Arctic."⁹¹ Moreover, it directs the US government to coordinate research in the polar regions through the Interagency Arctic Research Policy Council (IARPC), US Arctic Resource Council (ARC) and non-governmental research institutions.⁹² Finally, it states oil, gas and other resource development will be conducted "...with accepted best practices and internationally recognized standards."⁹³

As surface minerals become scarce and mineral prices rise, undersea mining should become more economically viable. One of the companies to explore and develop technologies for deep seafloor mining is Nautilus Minerals through its Solwara 1 Project, "...utilizing technologies from the offshore oil and gas, dredging and mining industries, the project will mark the launch of this new deep water seafloor resource production industry."⁹⁴ Though undersea mining uses nascent technology, even less is known about the natural environment on the bottom of the ocean and potential impact of undersea mining. 30 US Code Chapter 26, the Deep Seabed Hard Mineral Resources Act, regulates deep seabed mining in the United States. Signed into law in 1980 and reauthorized in 1986, this act establishes deep undersea mining operation regulations, requires environmental assessment of associated operations and encourages R&D in the area.⁹⁵

As opportunities in nanomaterials grow, Arctic Ocean development and undersea mining will become more feasible. The US government can undertake several actions to facilitate this

progress. In nanotechnology, the government should consider: funding "high risk/high reward" R&D initiatives; partnering with academia and industry to move technology from laboratory-to-market place more expeditiously; and closing the current policy gap by establishing policies and regulations that support this effort. In the Arctic Ocean, the United States should ratify the UNCLOS to expand its EEZ to enhance its ability to use and regulate seabed resources within these "new" boundaries. Participation in the Arctic Council, IARPC and US ARC to develop technology and environmental regulations for responsible growth in the Arctic should continue. Lastly, in undersea mining, improved information-sharing among government, academia and industry can enhance undersea mining technology. The US government should also be prepared to update its laws regulating undersea mining to reflect changes in technology and environmental impacts more accurately. Making economic, scientific and human capital investments in these three areas contributes to securing national economic and environmental security.

Collaboration, Information-Sharing and Networking

It is in the best interest of the United States to communicate strategically with its partners and allies. Strategic alliances and thoughtful partnerships help influence global opinion and secure equal footing amongst fierce global competition for limited resources. Integrating more effectively within the international community leverages the benefits of globalization. Some of these benefits include market access and trade; academia and industry partnerships; participation in crafting large-scale solutions to access strategic materials; and enhanced information sharing. Leveraging better collaboration and networking with partners may better position US influence on strategic materials, advance capabilities and meet economic objectives by mitigating the risks to long-term security interests.

Key issues in developing an effective approach to assure the availability of strategic materials include defining the scope of industries/sectors and relevant players. To date, different US government agencies [e.g., the White House Office of Technology Policy and the Departments of Defense (DoD), Energy (DoE) and Commerce (DoC)] have produced studies to define materials considered *strategic* or *critical*. In the current budget-conscious period, it makes sense to develop a comprehensive "whole-of-government" approach to define risk and ensure that government, private sector and academic experts collectively develop a common vision rooted in today's increasingly complex economic environment. Given the increasing interdependence among countries to access strategic materials, it is also prudent to consider creative approaches and promote innovation to secure US resources. International partnerships and public-private partnerships address multiple objectives and leverage the power of creativity.

The authors recommend that representatives from the White House (Office of Technology Policy, National Security Council and National Economic Council), Department of State and other relevant Departments, key industries (e.g., mining, metals, aircraft and electronics), and a few academics should be consulted to help develop strategic policy. A combination of representatives from government, private sector, academia and other key stakeholders would facilitate policies that consider a full range of information and reflect "real world" solutions.

The group's key functions would be to gather feedback on how US government policies help or hinder the goal of reducing risks that US industry faces in accessing strategic materials and implementing US policies that best reduce these risks. The effort should be to maximize use of market forces to encourage availability of resources related to the US defense sector. Strategic



material stockpiles engender monetary costs; therefore, policy incentives that encourage development of indigenous resources or secure access to international sources are desirable.

Communicating with strategic materials firms and stakeholders adds value. These groups can provide valuable insights into: world market price fluctuations; overly burdensome processes (e.g., obtaining mining permits); complicated regulatory requirements (e.g., EPA and DoL); financial responsibilities and liabilities (e.g., the Superfund program⁹⁶); raw material supply data (e.g., labor and energy costs); public perceptions of the mining business (e.g., perceived or actual negative environmental impacts); difficulties in securing qualified personnel; and issues with corporate tax rates (e.g., ~40%, the 2nd highest rate in the world).⁹⁷ In essence, collecting input from various industries and stakeholders helps government officials and policymakers make better business decisions, identify alternatives and understand broader global concerns.

International partnerships also offer opportunities for strengthening access to strategic materials. For instance, the DoD Task Force for Business and Stability Operations (TFBSO) is assisting the Government of Afghanistan in packaging opportunities for international investors to develop mineral resources in Afghanistan. These partnerships offer low-cost options for incentivizing US company investments overseas and opportunities to establish public-private partnerships among economically depressed countries, the US government and private industry. Similarly, outreach with key industry groups (e.g., National Mining Association, National Association of Manufacturers or US and Afghanistan Chambers of Commerce) should continue to support economic development and facilitate closer political ties with partner governments.

Partnering with Industry

In addition to partnering with other governments, partnering with commercial industry is fundamental. National defense is linked inextricably to the health of the US defense and industrial base. When its strategic materials manufacturing or processing industries are weakened, the nation's ability to innovate and develop advanced technology deteriorates, further jeopardizing US national and economic security.

In general, a stable supply of natural resources and raw materials is essential to US industrial capacity. Some materials categorized as *strategic* (or *critical*) are vulnerable to supply-chain disruptions when supply availability or scarcity issues arise. These situations are associated with a lack of substitutes or alternate materials in the foreseeable future. Although specific materials in this category may change as technology involves, time and the perceived level of criticality help influence the speed of technological advancement and amount of investment to accelerate desired changes. Materials required for key industries (e.g., aerospace) or used in strategically important growth industries (e.g., clean energy technology) often receive attention. Materials needed to sustain national defense capabilities require significant consideration.

Industry sees securing strategic materials as only one segment in the supply chain to manufacture finished products. The overall supply chain generally falls into the following four phases: Pre-Mining; Mining and Separation; Intermediate Processing; and Manufacturing of Finished Products. To develop effective strategic materials policy, the US government should consider and analyze information from all segments.

Using innovation to improve the efficiency of production is important to maintaining the global competitiveness of US business. Intellectual property rights and companies' "trade secrets" also are indispensable to sustaining competitive advantage. In accordance with US National Security

Strategy, the United States should enhance science, technology and innovation by investing in its research capabilities and expanding its international science partnerships.⁹⁸ If specific finished products serve industrial applications in large commercial sectors, market forces usually prevail without government support or interference. However, more active government support (e.g., subsidies or tariffs) may assist in establishing or preserving a "level playing field." This may be a necessity when the US government is the major customer (e.g., dominates market purchases). Regardless, government support should be limited and tailored on a case-by-case basis. By assessing the inherent nature of strategic materials, better decision-making can prevail—even if DoD is the major end user that determines the market's demand. A strong strategic materials industry supported by sustainable market power and private innovation bolsters US economic power and shores up national security.

At the same time, the United States should diversify sources through global supply chains with its partner nations. Fostering global relationships, encouraging commercial firms to invest more in R&D and collaborating with industry all positively impact long-term economic interests. National security rests on the freedom to produce goods and services, expectation of economic stability and ability to modernize US technology in a globally competitive world. The United States can ill afford to have a myopic or US-centric view that ignores today's intense rivalry, which seeks to control profitable mining markets and stake out early positions. Near peer competitors, like China, seek innovative ways to shore up their competitive edge and leverage being first to market, and benefit from policies that take a long-term view, often seeking to achieve objectives over decades. The United States should recognize that other countries often possess more supportive policies towards industry, which allow these countries to seize potentially more lucrative deals and benefit significantly from mining technology opportunities. Being cognizant of the likely ramifications of suboptimal—or less supportive—industry engagement better positions US companies globally, enables these firms to compete more successfully and improves the chances the US strategic materials industry will be able to survive in the global market over the long haul. Including the private sector as part of the strategic material dialogue expands perspectives, increases access to potential ideas and contributes to constructive debate regarding supply chain expectations and objectives.

"But steady, intense, relentless innovation is essential; newness of ideas and institutions should be a measure we use to see how successful we have been in adapting a deep-security outlook."
—Joshua Cooper Romo, The Age of the Unthinkable, 2011⁹⁹

CHAPTER VIII: CONCLUSION

It is imperative US government officials and policymakers understand the spectrum of national security implications regarding strategic minerals and the materials produced from them, particularly before they become limited or unavailable, through either scarcity or denial. The connectedness, characterized by sprawling multinational companies enabled by technological advances and globalization, is inextricably interweaving national economies. These changes make policy decisions increasingly difficult. Decisions must be weighed carefully as they have direct and indirect impacts on national security and are often mired in the US political process.

Although difficult, the US government should use apolitical analytic rigor to separate perceived risk from real risk. Given the advantage of the United States' strong links to the global economy, the US government should seek solutions that balance government intervention and protectionist solutions. This analytical rigor encompasses a broad definition of national security, one that

treats US political, economic and growth imperatives equally with defense considerations. The legislative branch must responsibly address the decline of US investment in exploration and strategic material activities. Identifying more rational governance approaches to incentivize desired behavior (e.g., investment in R&D, environmental innovation and emerging technology) will contribute to US competitive advantage and reap other short- and long-term benefits.

By labeling a material *strategic* or *critical*, the United States communicates, internally and externally, something about its priorities. In theory, US policy, laws and regulations would align to support these priorities. In reality, stated priorities and policies are often misaligned because of competing interests, both domestically and internationally. This misalignment creates disconnects in US strategic materials policy. The US government should also work with industry to analyze supply chain nodes (upstream and downstream) and assess the level of risk, especially where key chokepoints and other vulnerabilities exist that may lead to unacceptable risk.

The rapid pace of technological innovation, and resultant ability of commercial industry to adapt by using substitute materials or alternative methods, compounds the complexity of US strategic materials policy. The US government must consider tradeoffs between cost, risk and lag times in supply and demand when making policy decisions. Effective US policymaking also considers all time implications—short-, mid- and long-term. Through risk mitigation assessments—*probability*, *consequence* and *velocity*—the United States protects its national security interests and hedges against supply restriction issues. Given the repercussions if the United States fails to guard against such pitfalls, these unintended consequences should also be addressed. In the end, compromises will be made—politically, socially, economically, environmentally and militarily.

While this research does not dive extensively into all of the social aspects of the strategic materials industry, future ICAF industry seminars may determine this to be an area of interest worth deeper analysis to assess the relationships among industry outreach, strategic communication initiatives, perceptions and the value of domestic and/or public support.

The US economic interests that reinforce national security (e.g., commerce, prosperity, economic stability, free trade and viable defense industrial and commercial bases) must be preserved and relentlessly monitored. More importantly, if the United States does not identify new ways to think about the strategic material "challenge" and develop feasible risk mitigation strategies to ensure reliable and cost-effective sources for these strategic materials, it may actually hamper the US economy and technological capacity and place national security in jeopardy in the long-term.

The United States strengthens its national security interests by: redefining the concept of a National Defense Stockpile (NDS); improving the understanding of the relationships among US policy, recycling and the environment; refining the concept of multinational supply chain management; adopting a more holistic policy approach that considers the US strategic materials industry and its relationship with emerging technologies and the international economic system; and creating enabling mechanisms for networks among the US government, industry, academia and international partners. Through these activities, the United States can proactively and comprehensively focus on mitigating any national security risks related to strategic materials.

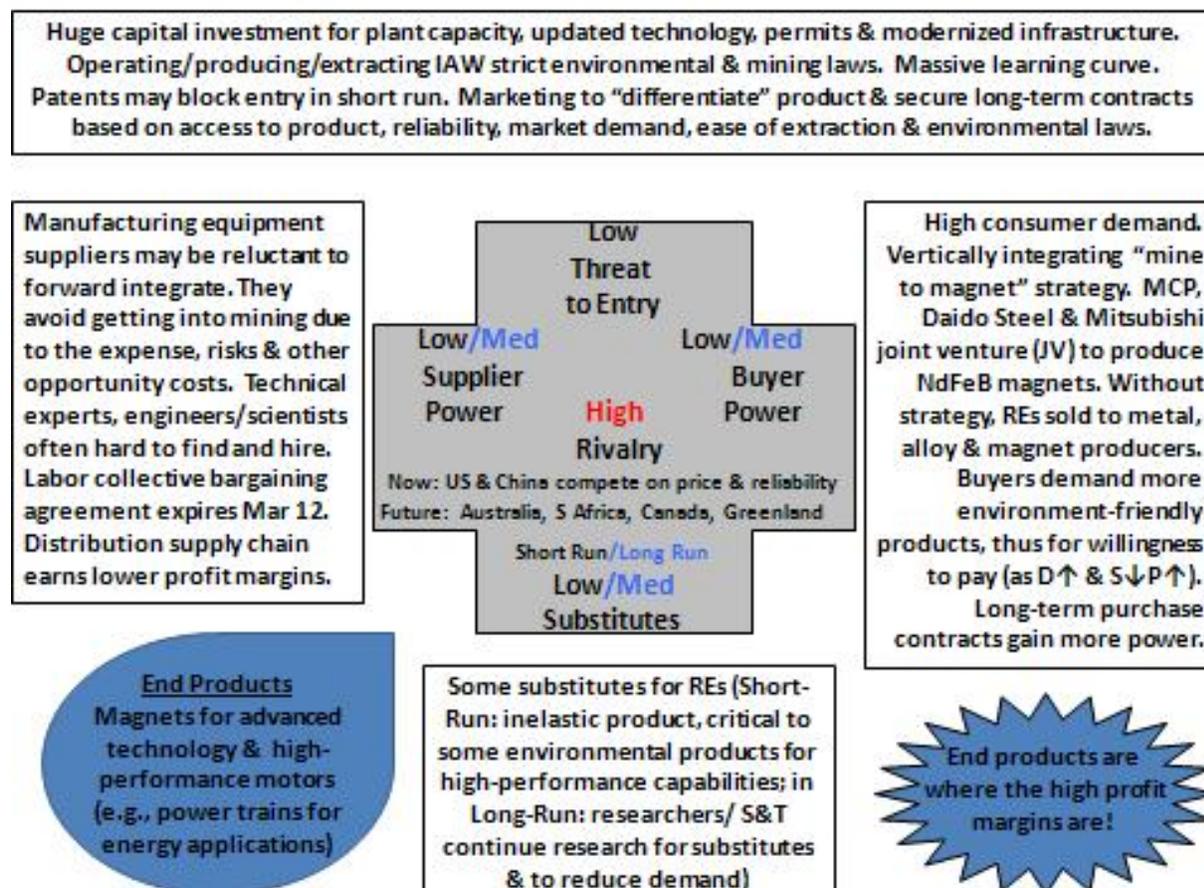
Quintessentially, and in accordance with the ICAF inscription, "Industria et Defensio Inseparabiles," industry and defense are inseparable. Ultimately, national defense and long-term security are strengthened by how well US policymakers understand the dynamic relationship of "strategic materials" and apply an analytical rigor to identifying and mitigating the risks.

**APPENDIX A: STRATEGIC AND CRITICAL MATERIAL DEFINITIONS USED IN
VARIOUS PUBLICATIONS**

2008 DoD SMPB Report to Congress	
<i>Strategic Material</i>	A material which is essential for important defense systems, unique in the function it performs, and for which there are no viable alternatives ¹⁰⁰
Material Critical to National Security (<i>Critical Material</i>)	A strategic material for which DoD dominates the market; requires DoD's involvement and support to sustain and shape the strategic direction of the market; and there is significant and unacceptable risk of supply disruption due to vulnerable US or qualified non-US suppliers. ¹⁰¹
2011 NDAA Expanded Definitions	
Material <i>Critical</i> to National Security	Materials upon which the production or sustainment of military equipment is dependent; and the supply of which could be restricted by actions or events outside the control of the Government of the United States. ¹⁰²
The 2011 NDAA Further Clarified	
Military Equipment	Equipment used directly by the armed forces to carry out military operations ¹⁰³
Secure Supply	As the availability of source, including the full supply chain for the material and components containing the material. ¹⁰⁴
National Research Council's Committee on Critical Mineral Impacts on the US Economy Report on <i>Minerals, Critical Minerals and the US Economy</i>	
A mineral is <i>critical</i> if it	Performs an essential function for which few or no satisfactory substitutes exist" reflecting "economic, social, and other consequences if essential functions cannot be delivered." ¹⁰⁵
Additionally a mineral can only be assessed as <i>critical</i> if an	Assessment also indicates a high probability that its supply may become restricted, leading to either physical unavailability or to significantly higher prices for that mineral in key applications. ¹⁰⁶
Department of Energy 2011 Critical Materials Strategy	
Uses the 2008 NRC review definitions but updates the definitions to focus on clean energy requirements. Thus for a material to be <i>critical</i> it must be critical to Clean Energy. ¹⁰⁷	
The report also addresses criticality in the short- and medium-term criticality. ¹⁰⁸	
Strategic Material	Specifically did not address as part of the report
The European Community Commissioned Paper <i>Critical Raw Materials for the EU</i>	
A raw material is <i>critical</i>	When the risk of supply shortage and their impact on the economy are higher than for most of the other raw materials. ¹⁰⁹
<i>Strategic Material</i>	Specifically did not address as part of the report

APPENDIX B: PORTER'S 5 FORCES EXAMPLE ANALYSIS

The following example illustrates the application of "Porter's 5 Forces Model" to Molycorp, Inc. at the operational business level.¹¹¹



APPENDIX C: ICAF STRATEGIC MATERIALS INDUSTRY REPORT ANALYSIS

The following chart is a compilation of the last 32 years of strategic materials industry reports.

Year	Name	Discussion of Stockpile	Recommendations
1980	No Report		
1981	Critical Materials	Stockpile is inadequate to meet requirements.	Stimulate investment via improved depreciation rules, review of regulations, continued open market system
1982	No Report		
1983	Strategic Materials	"Appropriation levels for the stockpile are grossly inadequate"	Develop stockpile improvement plan, stockpile management should be isolated from political pressures, OSD produce valid quantifiable requirements, barter, economic incentives
1984	Strategic Materials	"Primary Weapon against material dependency"	Expand barter, cycle existing stocks, pursue tax relief and other incentive to encourage greater industrial stocks
1985	Strategic Materials	"Stockpile is perennially underfunded"	Barter, fund stockpile, recycle/substitute, encourage domestic sources
1986	No Report		
1987	No Report		
1988	Selected Materials	Policy and management of the NDS shifted from FEMA to GSA/DoD.	Study material industries on a global basis, meet with allies on selected materials, participate in international commodities organizations, conduct comparative studies of essential material management
1989	Critical Materials	"The Administration's philosophy of free market economics seems to be satisfying the needs as we now know them."	Establish a Hemispheric Approach to supply, foster better relations within the western hemisphere, leverage supply in our hemisphere, investigate need for a NDS.
1990	Critical Materials	Lack of a relevant global database, no one Federal Agency has sole responsibility	The Federal Government needs a national-level policy planning and coordinating unit. Countries which lack the natural resource base in critical material must seek to meet requirements through stockpiling, substitutions, offshore purchase of raw materials or importation of finished goods.
1991	Critical Materials	NDS is continuing to be operated without a stated, comprehensive, national minerals policy	Administration must forge a comprehensive national policy, provide multi-year materials plan and budget, reestablish the ceiling on the NDS transaction fund to \$500 mil to allow manager greater flexibility in purchasing during favorable times and decrease inventory stock.
1992	No Report		
1993	Advanced Materials		Develop a well thought-out, overarching, technology policy. Restructure regulation and procedures to facilitate technology transfer. Recognize realities of a global, transnational economy and develop strategies for effective competition. Fund research and development spending.
1994	Advanced Materials	We must change the National Stockpile to conform to what is actually occurring in our world.	Find a way to keep the composition of the NDS on the forefront of technological applications. The nation should move to a smaller, more industry responsive stockpile.

Year	Name	Discussion of Stockpile	Recommendations
1995	Advanced Materials		Continue to fund R&D and work to promote joint public private ventures.
1996	Advanced Materials	The US should not have difficulty gaining access to AMAT's.	Forge a positive domestic economic environment conducive to growth and investment. Protect intellectual property. ID and evaluate US national security vulnerabilities and support AMATs industrial base deemed critical to national security and vulnerable to foreign pressures or loss of access.
1997	Strategic Materials	The absence of any threat calls into question many of the programs that support our defense and national security.	
1998	Strategic Materials	We recommend the materials stockpile continue to be phased down in a gradual, responsible manner.	Where stockpiles may be needed for any protracted war contingency, we recommend that incentives be developed to privatize the stockpile.
1999	Strategic Materials		Gather experts to do an annual conference and develop a national minerals policy. United States should take lead to develop a global materials policy.
2000	No Report found		
2001	Strategic Materials	NDS remains a viable means of ensuring the availability of strategic materials when confronted with the threat of geopolitical instability and/or economic disruption.	DoD must abandon "business as usual" approach and seek to shape the stockpile in order to posture America's armed forces to meet the challenges of the future. There is a need for a process that continuously analyzes materials developments and materials processing.
2002	Strategic Materials	No stockpile discussion	
2003	Strategic Materials		Strengthen intellectual property rights, increase funding for R&D, improve STEM initiatives and funding, promote free trade and open global markets.
2004	Strategic Materials	Only 3 materials are currently required for stockpiling - beryllium metal, quartz and mica. The reduced reliance on a national strategic and critical material stockpile recognized the reality of globalization. The US is whole or partially dependent upon the global marketplace for many of today's material needs. We recommend the government continue to sell off our aging physical stockpile	Establish a "virtual stockpile" whereby a comprehensive list of substitutes for strategic material can be identified and surged capabilities ensured. Include Civil Reserve Air Fleet like agreement with domestic source and formal agreements with foreign source. Exercise the "Virtual Stockpile" plan to ensure it works. Consider stockpiling Rare Earth Elements to ensure a steady supply without total dependence upon China.
2005	Strategic Materials	From a commercial standpoint, we found that stockpiling is no longer popular. Companies have implemented long-term contracts with their strategic suppliers, including international sources, to limit supply disruptions and reduce price variability.	The United States must move forward with a revitalized strategy that will position it to compete. Need to reassess stockpile policy and produce a board policy which considers: current defense war-planning construct to include homeland defense, rise of economic peer competitors, the defense transformation (reliance on REE and super alloys) and the need to assure accessibility, availability and affordability of strategic materials.

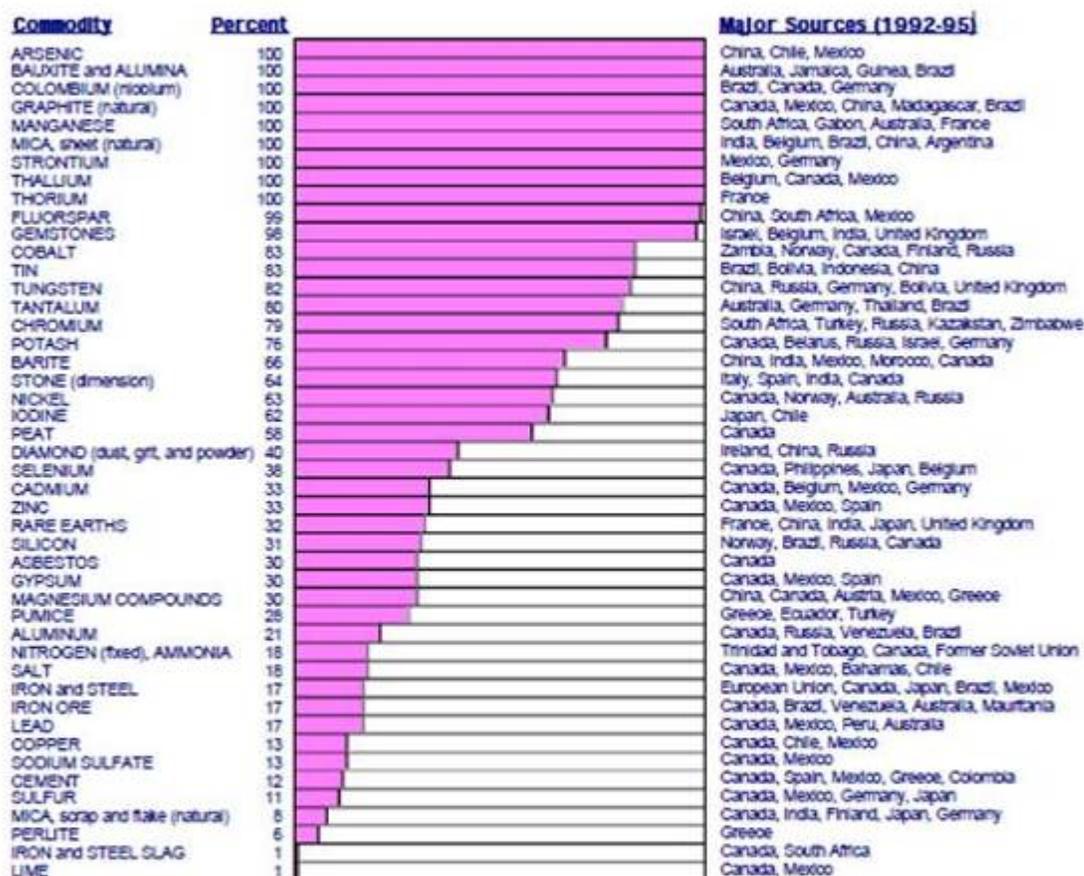
Year	Name	Discussion of Stockpile	Recommendations
2006	Strategic Materials	While understanding a potential material-access problems is important, US government interventions to hedge against strategic shortages, such as the national defense stockpile and the strategic petroleum reserve, have been ineffective in accomplishing their intended goals (Taylor & Van Doren, 2005; GAO, 2001, ICAF 2006 Industry Report)	The industry that provides material with strategic value for the nation remains relatively healthy. Need to emphasis free-market principles. US government role should be to developing breakthrough materials. No need for more government intervention; government involvement with industry should be limited to addressing strategic needs that market forces cannot satisfy.
2007	Strategic Materials	Establishing a stable, agile national stockpile of material mitigates the threat to national security. The new Strategic Material Protection Board is a major step in the right direction.	Revisit the processes used to assess and manage global strategic material to include a revitalization of the NDS. Conduct a comprehensive assessment of the global value chain supporting US defense efforts. Improve R&D and education. Harmonize legislation that affects strategic materials.
2008	Strategic Materials	The changing nature of the worldwide marketplace via globalization and "free access" to critical minerals make the US economy more vulnerable to supply chain disruptions due to events beyond our shores. At present, there is a worldwide shortage of many of the items we sold from our NDS.	We agree with the conclusion of the Committee on Assessing the Need for a Defense Stockpile that the "design, structure and operation of the NDS render it ineffective in responding to modern needs and threats" A complete overhaul of guidance and operating authorities is needed to make a more flexible, market oriented structure. Create a Minerals Policy Coordination Committee (PCC), create a Critical Minerals National Policy and institute a Critical Minerals Partnership that provides a medium for the government and industry to collaborate on strategic materials issues.
2009	Report not published		
2010	Strategic Materials	"The current stockpile statutory management structure may not be sufficiently flexible to respond to the critical defense needs."	Stockpiling practices should be modernized. Need to invigorate trade negotiations with other countries and secure agreements for long term access to minerals and metal critical to national security. Partner options with friendly countries to ensure stability of supply. Free markets should be encouraged.
2011	Strategic Materials	Over the years stockpiling has proven to be ineffective. (DLA SMSP Implementation Plan). Very few examples when the stockpile was used for its intended purpose. Legislations have tied the hands of the stockpile manager. Formation of the SMSP in 2010 postponed until NDAA FY13.	In 2010, the National Science and Technology Council (NTSC) chartered the Critical and Strategic Mineral Supply Chain Sub-Committee of the Committee on Environment, Natural Resources and Sustainability. Need to make this a principals committee co-chaired by Director of the Office of Science and Technology Policy and another cabinet-level official. New office should be permanently staffed with right expertise and serve as an integrator among academia, public and government officials.



APPENDIX D: 1996 VS. 2011 US NET IMPORT RELIANCE FOR SELECTED NONFUEL MINERAL MATERIALS¹¹²

The following two tables identify the United State's net import reliance on nonfuel mineral materials for 1996 and 2011 as reported by USGS.

1996 U.S. NET IMPORT RELIANCE FOR SELECTED NONFUEL MINERAL MATERIALS



¹ In descending order of importance

Additional commodities for which there is some import dependency include:

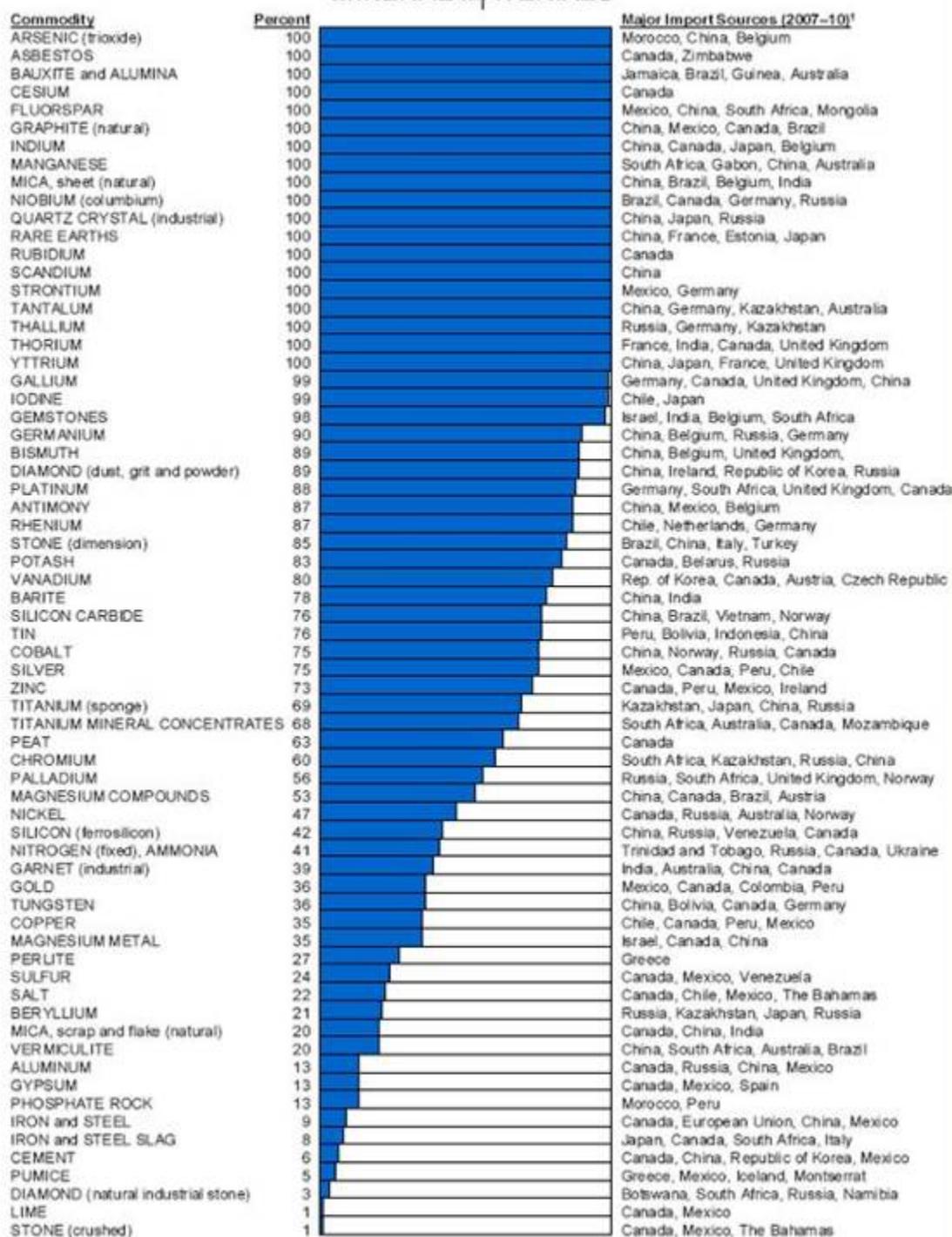
Antimony	China, Bolivia, Mexico, South Africa
Bismuth	Mexico, Belgium, China, United Kingdom
Gallium	France, Russia, Germany, Hungary
Germanium	China, United Kingdom, Ukraine, Russia, Belgium
Ilmenite	South Africa, Australia, Canada
Indium	Canada, France, Russia, Italy
Kyanite	South Africa
Mercury	Russia, Canada, Kyrgyzstan, Germany

Platinum	South Africa, United Kingdom, Russia, Germany, Belgium
Rhenium	Chile, Germany, Sweden
Rutile	Australia, South Africa, Sierra Leone
Silver	Mexico, Canada, Peru, Chile
Titanium (sponge)	Russia, Japan, China, Ukraine
Vanadium	South Africa, Canada, Russia, Mexico
Vermiculite	South Africa
Zirconium	Australia, South Africa



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2011 U.S. NET IMPORT RELIANCE FOR SELECTED NONFUEL MINERAL MATERIALS



¹In descending order of import share.



APPENDIX E: US FEDERAL MINING & MINERAL PRODUCTION LAWS

The following table lists some of the major US federal mining and mineral production laws.

Federal Mining Law	Governs mining on federal public lands.
National Environmental Policy Act	Requires an interdisciplinary approach to environmental decision making
Federal Land Policy and Management Act	Prevents undue and unnecessary degradation of federal lands
Clean Air Act	Sets air quality standards
Federal Water Pollution Control Act (Clean Water Act)	Directs standards for surface water quality and controlling discharges to surface water
Safe Drinking Water Act	Directs standards for quality of drinking water supplied to the public (states are primary authorities) and regulating underground injection operations
Solid Waste Disposal Act	Regulates generation, storage and disposal of hazardous waste and manages solid, non-hazardous waste (states)
Comprehensive Environmental Response, Compensation and Liability Act	Requires reporting of hazardous substance releases and inventory of chemicals handled
Toxic Substance Control Act	Requires regulation of chemicals that present risk to health or environment
Endangered Species Act	Lists threatened plants and animals; protection plans mandated
Migratory Bird Treaty Act	Protects nearly all bird species
Surface Mining Control and Reclamation Act	Regulates coal mining operations and reclamation
Other laws impacting mining include: Rivers and Harbors Act, Federal Mining Law, National Historic Preservation Act, Federal Mine Safety and Health Act, and the Law Authorizing Treasury's Bureau of Alcohol, Tobacco and Firearms to Regulate Sale, Transport and Storage of Explosives	

NOTES

- ¹ George Otis Smith, *The Strategy of Minerals: Problems of War and of Reconstruction* (New York: D. Appleton and Company, 1919): vii.
- ² G.W. Featherstonhaugh, "Letter dated January 12, 1833, to Lewis Cass, Secretary of War", in *Public documents of the Senate of the United States: US Congress, 22d, 2d Session*, v.1, Document 35, (Washington DC 1833), 5-7.
- ³ Tom Vulcan, "What the US Deficiency in Rare Metals Means for Markets... and What You Need to Know," *Seeking Alpha*, July 19, 2010, <http://seekingalpha.com/article/215189-what-the-u-s-deficiency-in-rare-metals-means-for-markets-and-what-you-need-to-know>.
- ⁴ *Minerals, Critical Minerals, and the US Economy*, (Washington DC: The National Academies Press, 2008), 31
- ⁵ US Department of Energy, *Critical Materials Strategy*, Annual Report, (Washington DC: US Department of Energy, 2010), 113
- ⁶ Executive Secretary to the Strategic Materials Protection Board USD(AT&L). *Report of Meeting DOD Strategic Materials Protection Board*. Washington DC: US Department of Defense, 2008. pg. 2.
- ⁷ *National Defense Authorization Act for Fiscal Year 2011, H.R. 6523 Ike Skelton*, Public Law 111-383, 111th Congress, 2010, <http://www.gpo.gov/fdsys/pkg/BILLS-111hr6523enr/pdf/BILLS-111hr6523enr.pdf>, Sec 829(a)(e).
- ⁸ Anonymous US Congressional Staffer, "Industrial College of the Armed Forces, Strategic Materials Industry Study Visit," *Industrial College of the Armed Forces*, Washington DC, April 11, 2012.
- ⁹ Ibid.
- ¹⁰ M.E. Porter, *The Five Competitive Forces That Shape Strategy*, Harvard Business Review, January 2008.
- ¹¹ "787 Program Fact Sheet," *Boeing Company*, accessed March 16, 2012, <http://www.boeing.com/commercial/787family/programfacts.html>.
- ¹² US Congressional Research Service, *The Buy American Act: Requiring Government Procurements from Domestic Sources*, Report RL 31236, March 13, 2009, 5.
- ¹³ US Congressional Research Service, *The Berry Amendment: Requiring Defense Procurement to Come from Domestic Sources*, Report RL 31236, March 13, 2009, 6.
- ¹⁴ Ibid., 9.
- ¹⁵ US Congressional Research Service, *The Specialty Metal Provision and the Berry Amendment: Issues for Congress*, Report RL 33751, October 5, 2010.
- ¹⁶ Ibid., 4.
- ¹⁷ Strategic and Critical Materials Stock Piling Act, US Code, Vol. 50, sec. 98a(b).
- ¹⁸ National Materials Advisory Board, *Managing Materials for a Twenty-First Century Military*, http://www.nap.edu/openbook.php?record_id=12028&page=135, (Accessed 26 Feb 2012), 135.
- ¹⁹ Ibid., 135.
- ²⁰ Ibid., 135.
- ²¹ Ibid., 138.
- ²² Ibid., 139.
- ²³ The SecDef then delegated authority to the Assistant Secretary of Defense for Production and Logistics, supervised by the Under Secretary for Acquisition, with operational activities managed

by Director of the Defense Logistics Agency. For more information see: National Materials Advisory Board, *Managing Materials for a Twenty-First Century Military*, 140-141.

²⁴ US Department of Defense, *Strategic and Critical Materials 2011 Report on Stockpile Requirements* (Washington DC: US Department of Defense, 2011), Table 1, 7-9.

²⁵ Valeria Bailey Grasso, "The Berry Amendment: Requiring Defense Procurement to Come from Domestic Sources", Congressional Research Service, Report RL31236, (Washington DC: Congressional Research Service, January 2012), summary – 6.

²⁶ Policy Archive, "The Berry Amendment: Requiring Defense Procurement to Come from Domestic Sources", Accessed 14 March 2012, <http://www.policyarchive.org/handle/10207/1325>.

²⁷ Grasso, "The Berry Amendment: Requiring Defense Procurement to Come from Domestic Sources", 1, 16-17.

²⁸ Grasso, "The Specialty Metal Provision and the Berry Amendment: Issues for Congress", *Congressional Research Service*, Report RL33751 (Washington DC: Congressional Research Service, 2008), summary.

²⁹ *National Defense Authorization Act for Fiscal Year 2007, Sec. 843, John Warner*, Public Law 109-364, 109th Congress, 2007, <http://www.gpo.gov/fdsys/pkg/PLAW-109publ364/pdf/PLAW-109publ364.pdf>, 2335-2338.

³⁰ *Ibid.*, 2338-2339.

³¹ *National Defense Authorization Act for Fiscal Year 2008, Sec. 804 and 843*, Public Law 110-181, 110th Congress, 1st Session, 2008, <http://www.dod.gov/dodgc/olc/docs/pl110-181.pdf>.

³² *National Defense Authorization Act for Fiscal Year 2007. Sec. 843, John Warner*, 2338-2339.

³³ US Department of Defense Strategic Materials Protection Board, "Report of Meeting Held on December 12, 2008," *Office of the Deputy Undersecretary of Defense for Industrial Policy* (Washington DC: US Department of Defense, February 23, 2009), 9.

³⁴ *Ibid.*

³⁵ *National Defense Authorization Act for Fiscal Year 2011, H.R. 6523 Ike Skelton*, 136-137.

³⁶ John R. Luckey, "The Buy American Act: Requiring Defense Procurement to Come from Domestic Sources," *Congressional Research Service*, Order Code 97-765 A (Washington DC: Congressional Research Service, 2008), 1-2.

³⁷ *Ibid.*, 3.

³⁸ *Buy American Improvement Act of 2007, S. 581*, 110th Congress, 2nd Session, 2007, <http://www.gpo.gov/fdsys/pkg/BILLS-110s581is/pdf/BILLS-110s581is.pdf>, 6.

³⁹ Luckey, "The Buy American Act: Requiring Defense Procurement to Come from Domestic Sources," 3.

⁴⁰ Daniel H. Else, "Defense Production Act: Purpose and Scope," *Congressional Research Service*, Report RS20587 (Washington DC: Congressional Research Service, May 2009), 1.

⁴¹ *Ibid.*, 1-2.

⁴² *Ibid.*, 4.

⁴³ *Defense Production Act Reauthorization of 2009*, Public Law 110-181, 111th Congress., 1st Session, September 30, 2009, <http://www.gpo.gov/fdsys/pkg/BILLS-111s1677enr/pdf/BILLS-111s1677enr.pdf>.

⁴⁴ "ITAR Self-Enforcement: How Much Do We Tell the Government?" *Export Rules*, March 6, 2011, <http://www.exporthrules.com/>.

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- ⁴⁵ John Morgan, *National Stockpile and United States Security* (Washington DC, Speech to the Industrial College of the Armed Forces, November 19, 1959), publication number L60-79, 2.
- ⁴⁶ "Strategic and Critical Materials Operations Report to Congress," *Office of the Under Secretary of Defense for AT&L*, January 2011, 1.
- ⁴⁷ US Government Accountability Office, "National Defense Stockpile," *Report to the Chairman, Committee on Armed Services, House of Representatives* (Washington DC: US General Accountability Office, January 2001).
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