NATIONAL CENTER FOR POLICY ANALYSIS

The Defense Implications of Rare Earth Shortages

Issue Brief No. 112 by Jeffery A. Green August 2012

Rare earth elements are used in everyday products: smart phones, hard disc drives, flat-screen televisions and advanced batteries. They are essential to such "green" technologies as wind turbines, compact fluorescent lights and hybrid cars. In today's world, which emphasizes cutting-edge and environmentally-friendly technologies, rare earths are everywhere.

Dallas Headquarters:
12770 Coit Road, Suite 800
Dallas, TX 75251-1339
972.386.6272

www.ncpa.org

Washington Office:
601 Pennsylvania Avenue NW,
Suite 900, South Building
Washington, DC 20004
202.220.3082

Furthermore, a range of highly advanced defense systems depend on rare earth phosphors, metals, alloys and magnets for their unique functionality. For example:

- The Ground Laser Target Designator, which allows infantrymen to guide munitions onto targets and estimate ranges, depends on neodymium-doped yttrium-aluminum garnets.
- Advanced jet aircraft engines rely upon thermal barrier coatings utilizing yttria-stabilized zirconia to shield metal components from extreme heat.
- Samarium-cobalt and neodymium-iron-boron ("neo") permanent magnets are used to move the fins of precision-guided munitions and, in combination with a terbium-iron-nickel alloy (with some dysprosium, also known as Terfenol-D), to mute rotor sound in helicopter stealth systems.[1]

Possible shortages of some rare earths, therefore, threaten our nation's defense systems.

Rare Earth Supply Chain. During the Cold War, U.S. companies encompassed the entire rare earth supply chain, from mining and chemical separation to metal-making and component manufacture. The Mountain Pass mine in California dominated rare earth production and General Motors invented the bonded neo magnet. Today, no U.S.-produced rare earth metals are sold commercially and only two firms can produce limited amounts of rare earth alloys. Two other companies can manufacture rare earth permanent magnets, but only of the samarium-cobalt type. Only one U.S. company mines and separates rare earths into oxides; however, this company reportedly intends to ship to China for processing unspecified amounts of its heavy rare earth concentrates — the feedstock for additives to samarium-cobalt and **neo** magnets.[2]

Today, as a direct consequence of active government support for the rare earth industry since the 1980s [see Figure I below]:[3]

- China produces more than 94 percent of the world's rare earth oxides, virtually 100 percent of all commercially available rare earth metals and more than 90 percent of the rare earth alloys.

- China manufactures three-fourths of the world's samarium-cobalt magnets and 60 percent of the neo magnets.

China has leveraged this quasi-monopoly to extract rents from the market by manipulating production and export quotas. For example:

- In 2002, the export quota for rare earth oxide-equivalents was 40,000 metric tons for domestic Chinese companies, and there was no quota for joint ventures with foreign companies.
- Since 2002, the quota has declined to 22,712 metric tons annually for domestic Chinese companies and 7,472 metric tons for joint ventures.[4]
- Simultaneously, China shifted from offering a value-added tax rebate to export rare earths in 2005 to imposing duties of 10 percent and 25 percent for certain products, progressively including more value-added rare earth products.[5]

The resulting volatility in prices, unavailability and two-tiered pricing structure (for exports versus domestic consumption) cast doubt upon the ability of today's supply chain to fulfill U.S. commercial or military requirements.

A 2010 Government Accountability Office (GAO) report highlighted very real national security concerns, noting that rebuilding the domestic supply chain from mining to magnet manufacture could take up to 15 years and was contingent upon capital investment and the expiration of certain patents.[6] Other reports — before and after the recommissioning of the Mountain Pass mine — echoed the GAO's concerns about the availability of critical materials.[7]

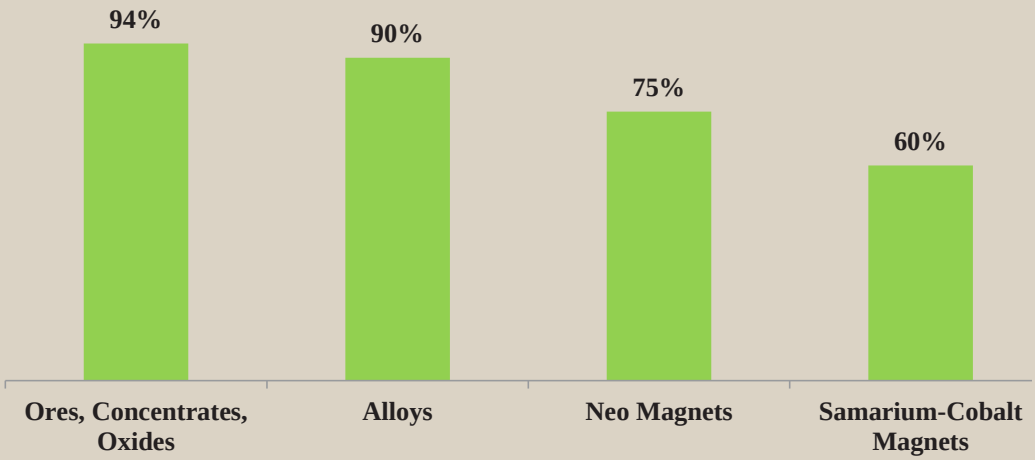
Supply-and-Demand Analysis. In a recent congressionally-mandated report on *Rare Earth Materials in Defense Applications*, senior Defense Department officials responded to the concerns of the GAO and others by claiming that supply shortages will be resolved by 2013.[8] However, the report leaves some important questions unanswered.

The Defense Department says it will rely upon the free market to ensure rare earth supplies. However, the market is not free; China has a near-monopoly. Indeed, the Chinese export policy described earlier provides distinct competitive advantages to domestic firms at the expense of foreign ones. China has alternately increased and restricted the supply of rare earths since the 1990s. In fall 2010, China demonstrated its ability to make targeted cuts in exports to reinforce other foreign policy goals when it interrupted supplies to Japan during a diplomatic dispute.[9] The report avoids this issue, and the word "China" does not appear at all.

Furthermore, the report's supply-and-demand analysis is considerably circumscribed, raising concern about its thoroughness. Figure II, reproduced from the report and obtained from publicly available sources, includes the department's original supply-and-demand forecast. There are no labels indicating the units measured — tons, metric tons and so forth — and the report does not indicate how these numbers were generated.

Figure I

China's Share of Rare Earth Magnets Supply Chain*



*China also controls almost 100 percent of the commercial sales of rare earth metals.

Source: Derived from "Rare Earth Materials in the Defense Supply Chain," Government Accountability Office, GAO-10-617R, April 14, 2010, and Pui-Kwan Tse, "China's Rare-Earth Industry," U.S. Geological Survey, USGS Report 2011-1042, 2011.

Moreover, some heavy rare earth elements, such as terbium (Terfenol-D), are not included.

However, the report concludes that U.S. production could satisfy defense procurement needs by 2013, with the exception of yttrium. Thus, the report seems to vindicate the Defense Department's past practice of relying on the market to resolve the supply chain problem. If supply is sufficient, then no change of strategy is necessary. However, this conclusion is inconsistent with the department's long-term, multi-prong plan to secure supplies: the Defense Priorities and Allocations System (DPAS).

Using DPAS, the Defense Department could stake a priority claim on U.S. supplies and imported materials to serve defense and national emergency preparedness requirements. This fallback position indicates that the Defense Department is unsure of the accuracy of its supply projections and anticipates the likelihood of using DPAS in a supply shortage, such as occurred in late 2010. This is a powerful disincentive for industrial investment in U.S. rare earths. Furthermore, even if the DPAS plan is implemented, the industrial base for high-purity metals, alloy, and magnet powders is so small that a bottleneck may result.

Figure II

Defense Department Rare Earths Supply-and-Demand Forecast

(metric tons rare earth oxide-equivalent)*

	Supply	Consumption	Surplus	Deficit
Dysprosium	7	7	0	
Erbium	1.2	1.14	0.056	
Europium	21	11	10	
Gadolinium	42	4	38	
Neodymium	2,232	110	2,122	
Praseodymium	824	14	810	
Yttrium	26	119		93

*"Metric tons rare earth oxide-equivalent" unit of measure inferred, based on personal communication by the author.

Source: Under Secretary of Defense for Acquisition, Technology and Logistics, Report to Congress Rare Earth Materials in Defense Applications, March 2012.

Private Sector Pressures and Defense Department Analysis. The assumptions about supplies of rare earths indicated in Figure II may not reflect the intricacies of the manufacturing process. The only mine in the United States poised for operations by 2013 is Mountain Pass. While this facility may fill the department's requirements for light rare earths (neodymium and praseodymium), recovery rates for the heavy rare earth elements (such as dysprosium and erbium) must approach 100 percent to fill predicted requirements.

Moreover, the department may be unaware of a series of other challenges. First, the owners of Mountain Pass have publicly acknowledged that all of its projected output is already precommitted to other customers.[10] Second, in briefing materials for the Congressional Rare Earth Caucus, the operators of Mountain Pass conceded that if they had not acquired certain processing facilities in China, it would have taken five to seven years to replicate that processing technology independently.[11]

In addition, while the Defense Department report seems to imply that one need only mine these materials, the actual manufacturing process requires multiple steps, each of which is a distinct engineering discipline. The analysis was supposed to cover these steps. It was also supposed to address the absence of U.S. companies throughout the neo magnet supply chain and the dependence of U.S. companies on unreliable foreign sources for the samarium-cobalt magnet supply chain.[12] The report failed to address these issues.

Risk Mitigation Plans. The Defense Department report did contain three action items. It called for consideration of a "buffer stock." Under ideal economic conditions, a buffer stock is accumulated before supplies become tight, when a product is cheaper, not built once availability has already become an issue. It also is somewhat difficult to ensure a domestically available flow of material when capacity is so limited. Though the demand for buffer stock could stimulate private investment, without adequate domestic capability the United States may be forced to buy at least some materials from Chinese companies or traders of Chinese materials.

The report also highlighted the importance of recycling and substitution. Though recycling fluorescent lighting and nickel-metal-hydride batteries could ease some raw material supply constraints, recycling is ill-suited to meet major defense applications, such as permanent

magnets. The economic viability of recycling magnets is questionable due to the need to melt and separate the metals from impurities. Furthermore, recycling raw materials for a product that cannot be produced by a U.S. company does not resolve the underlying problem. Moreover, the cost of investing in recycling and substitution, combined with the cost of retrofitting existing defense systems with substitute parts and requalifying those legacy systems is particularly high relative to investment in the supply chain. Thus, recycling is an important but limited solution.

Improving the Terms of Trade. The Defense Department report concludes that the pending World Trade Organization (WTO) case against China for its export quotas, duties and other policies, which distort rare earths prices and supplies, will result in an easing of supply. However, even a completely successful resolution of the WTO case is approximately two years away. By that time, industry experts project that China may be a net importer of rare earths.[13]

For decades, China served as the world's rare earth raw material supplier. Currently, China has a two-tier pricing scheme to draw downstream manufacturers — like GE Lighting and Showa Denko — to China, which also makes non-Chinese mining projects — such as Mountain Pass — more economically viable. By the time the WTO case is resolved, however, the main function of the rest of the world's rare earth mines could be to supply China-based high value-added manufacturers.

On the other hand, if China wins the WTO dispute, it may continue to impose production and export quotas unpredictably. Another possibility is a draw, wherein China could relax light rare earth exports while increasingly restricting exports of more critical heavy rare earths. This would mirror existing export quotas by distinguishing light rare earth from heavy rare earth products — greatly inhibiting resource development by driving down prices for the increasingly prevalent light rare earths while hurting downstream manufacturers by restricting the unique heavy rare earths.

The Way Forward. Despite these concerns, members of Congress remain focused on developing a comprehensive solution to address supply chain vulnerabilities. The House of Representatives' version of the National Defense Authorization Act for Fiscal Year 2013 creates new duties for the Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy, including oversight of policy and of Defense Department critical materials-related activities, as well as ensuring a secure supply of critical materials. The House bill explicitly mentions rare earth elements. It also requires recommendations to prevent the export to China of heavy rare earth elements from recycled U.S. government fluorescent lighting.[14]

Conclusion. One of the tremendous benefits of globalization has been the opening of world markets to American products, but the concomitant pursuit of the lowest cost raw materials has begun to adversely affect national security — as have imports of low-cost counterfeit electronic parts. There is a silver lining though. With sound domestic policies, we can reconstitute the capability to meet defense demands, but only when the Defense Department and concerned elected officials (whose ranks are now swelling) work together.

Jeffery A. Green is the founder of the Strategic Material Advisory Council and an adjunct scholar with the National Center for Policy Analysis.

References and sources can be found in the online version at www.ncpa.org/pub/ib112.

About the NCPA

The National Center for Policy Analysis (NCPA) is a nonprofit, nonpartisan public policy research organization, established in 1983. Our goal is to develop and promote private, free-market alternatives to government regulation and control, solving problems by relying on the strength of the competitive, entrepreneurial private sector. We bring together the best and brightest minds to tackle the country's most difficult public policy problems — in health care, taxes, retirement, small business, and the environment. In doing so, we propose reforms that liberate consumers, workers, entrepreneurs and the power of the marketplace.