Rare Earth Elements in National Defense: Background, Oversight Issues, and Options for Congress

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Summary

Some Members of Congress have expressed concern over U.S. acquisition of rare earth elements that are used in various components of defense weapon systems. Rare earths are a collection of 17 elements on the periodic table, including a series of 15 elements beginning with atomic number 57 (lanthanum) and extending through number 71 (lutetium), as well as two other elements, yttrium and scandium, which have similar properties. These elements are referred to as "rare" because while they are relatively abundant in total quantity, they appear in low concentrations in the earth's crust and economic extraction and processing is both difficult and costly.

From the 1960s to the 1980s, the United States was the leader in global production of rare earths. Since that time, production of the world's supply of rare earths has shifted almost entirely to China, in part due to lower labor costs and lower environmental standards. China produces about 97% of rare earth oxides, is the only exporter of commercial quantities of rare earth refined metals, and is the majority producer of the world's two strongest magnets (samarium cobalt (SmCo) and neodymium iron boron (NeFeB) permanent rare earth magnets). However, Molycorp, a U.S. company with mining operations in Mountain Pass, CA, recently announced that it restarted limited mining operations in December 2010 and has secured the final permits needed to construct a rare earth manufacturing facility, which is scheduled to open in 2012.

A series of events and press reports over the last few months have highlighted the rare earth "crisis," as some refer to it. Policymakers are concerned with the nearly total U.S. dependence on China for rare earth elements, including oxides, phosphors, metals, alloys, and magnets, and its implications for U.S. national security. The criticality and reliability of the rare earth element supply chain cuts across the manufacturing, defense, and science and technology sectors of the global economy. Some Members of Congress support development of a domestic source for rare earth elements. They view a reliable domestic supply chain as critical to maintaining existing and acquiring new defense weapons systems. Other policymakers see the existence of alternative sources for rare earth elements outside of China as a possible solution to mitigate a lack of domestic mining and manufacturing capability.

Yet the "crisis" for many policymakers is not that China has cut its rare earth exports and appears to be restricting the world's access to rare earths, but that the United States has lost its domestic capacity to produce strategic and critical materials. The Department of Defense (DOD) is examining whether there is a supply chain vulnerability issue. DOD estimates that the United States uses about 5% of the world's production of rare earths for defense purposes. Congress awaits the release of the overdue assessment by DOD of the rare earth supply chain. In addition to the previously required DOD assessment, Congress has also mandated that the Secretary of Defense, pursuant to the Ike Skelton National Defense Authorization Act for Fiscal Year 2011 (P.L. 111-383), conduct a new assessment of the rare earth supply chain issues and develop a plan to address any supply chain vulnerabilities.

There are important questions with only partial answers at the present time. Given congressional interests in rare earths, Congress may use its oversight role to seek more complete answers to the following important questions:

- Is there a rare earth material vulnerability that will impact national security?
- Are there substitutes for rare earths that are economic, efficient, and available?

- What short-term and long-term options might DOD consider in response to a lack of domestic production and China's continued dominance in this area?

In addition to requiring DOD to assess rare earth supply chain vulnerability issues, Congress may want to consider alternatives including

- development of a domestic rare earths stockpile;
- government investment in rare earths production, including various aspects of its supply chain; and
- partnering with foreign allies to diversify rare earth sources and decrease dependence on China.

Congress may encourage DOD to develop a collaborative, long-term, well-thought-out strategy designed to identify any material weaknesses and vulnerabilities associated with rare earths and to protect the long-term national security interests of the United States.

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Introduction

This report discusses rare earth elements used in Department of Defense (DOD) weapon systems, current problematic oversight issues, and options for Congress to address these issues. Rare earth elements (also referred to by the shorthand term "rare earths") include the lanthanide series of 15 elements on the periodic table, beginning with atomic number 57 (lanthanum) and extending through element number 71 (lutetium), as well as yttrium and scandium. These 17 elements are referred to as "rare" because while they are relatively abundant in quantity, they appear in low concentrations in the earth's crust and economic extraction and processing is both difficult and costly.

The United States is a major consumer of products containing rare earth elements. They are incorporated into many sophisticated technologies with both commercial and defense applications. From the 1960 to the 1980s, the United States was the leader in global production of rare earths. Since that time, processing and manufacturing of the world's supply of rare earths and downstream value-added forms such as metals, alloys, and magnets have shifted almost entirely to China, in part due to lower labor costs and lower environmental standards. Today, the United States lacks rare earth mine production, and almost entirely lacks the refining, fabricating, and alloying capacity to process rare earths. However, Molycorp, a U.S. company with mining operations in Mountain Pass, CA, recently announced that it restarted limited mining operations in December 2010 and has secured the final permits needed to construct a rare earth manufacturing facility, which is scheduled to open in 2012. The Japanese government also is investing in the rare earth industry in order to secure access to oxides, metals, and alloys.

A series of events and ensuing press reports have highlighted the rare earth "crisis," as some refer to it. In July 2010, the China Ministry of Commerce announced that China would cut its exports of rare earth minerals by 72%. In September 2010, China temporarily cut rare earth exports to Japan apparently over a maritime dispute. This dispute highlighted the potential for disruption of the world's supply of rare earth minerals. For 2011, it appears that China has cut exports further and raised export tariffs for rare earths. Some reports estimate that between 2012 and 2014, China's domestic consumption of rare earth elements will outpace its production, which could cause China to halt rare earth exports altogether. Other countries are trying to figure out how to react to these developments and how to protect their long-term interests in rare earths.

Some Members of Congress are concerned with the nearly total U.S. dependence on foreign sources for rare earth elements and the implications of this dependence for national security. Congress has been interested in the rare earth issue largely because

- the world is almost wholly dependent on a single national supplier—China—for rare earths;
- the United States currently produces approximately 3% of its light rare earth oxides;
- the United States has no production of heavy rare earths (terbium to lutetium and yttrium);
- the United States has virtually no production of rare earth metals, powders, alloys, and NeFeB magnets;

- there may be repercussions if these materials are not available for commercial and defense applications; and
- the rare earths supply chain vulnerability question may adversely affect the ability of the United States to plan strategically for its national security needs.

Congress required the Government Accountability Office (GAO) to examine rare earths in the defense supply chain and also required the Secretary of Defense to assess the defense supply chain and develop a plan to address any shortfalls or other supply chain vulnerabilities, including a specific requirement to present a plan for the restoration of domestic NeFeB magnet production. GAO concluded that revamping the defense supply chain could take 15 years or more. DOD has not yet released its assessment (which was promised for September 2010) to Congress on the defense supply chain issues, and it is uncertain whether the long-awaited DOD report will sufficiently address congressional concerns. In addition to the previously required DOD assessment, Congress has also mandated that the Secretary of Defense, pursuant to the Ike Skelton National Defense Authorization Act for Fiscal Year 2011 (P.L. 111-383), conduct a new assessment of the rare earths supply chain issues and develop a plan to address any supply chain vulnerabilities.

Congress may want answers to at least four important questions with regard to rare earth elements: (1) Are rare earth elements essential to U.S. national security? (2) How would a scarcity of rare earths affect the delivery or performance of defense weapon systems? (3) Is the United States vulnerable to supply disruptions, and if so, are there readily available and equally effective substitutes? (4) What are the short-term and long-term options that DOD may consider in response to a lack of domestic rare earth element production and China's continued dominance in this area?

Background on Rare Earth Elements

What Are Rare Earth Elements?

According to the U.S. Geological Survey (USGS),[1] there are 17 rare earth elements on the periodic table. The first 15 elements begin with atomic number 57 (lanthanum) and extend through element number 71 (lutetium), and there are two other elements, yttrium and scandium, which have similar properties. Rare earths are not particularly rare but are found in low concentrations in the earth's crust. The economics of locating and retrieving them are challenging. Rare earths are divided into two groups: light rare earths (lanthanum, cerium, praseodymium, neodymium, promethium, samarium) and heavy rare earths (europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium, scandium, and yttrium).

[1] USGS Fact Sheet 087-02, and USGS Mineral Commodity Summaries, January 2010, http://pubs.usgs.gov/fs/2002/fs087-02/.

How Are Rare Earths Used in Defense Applications?

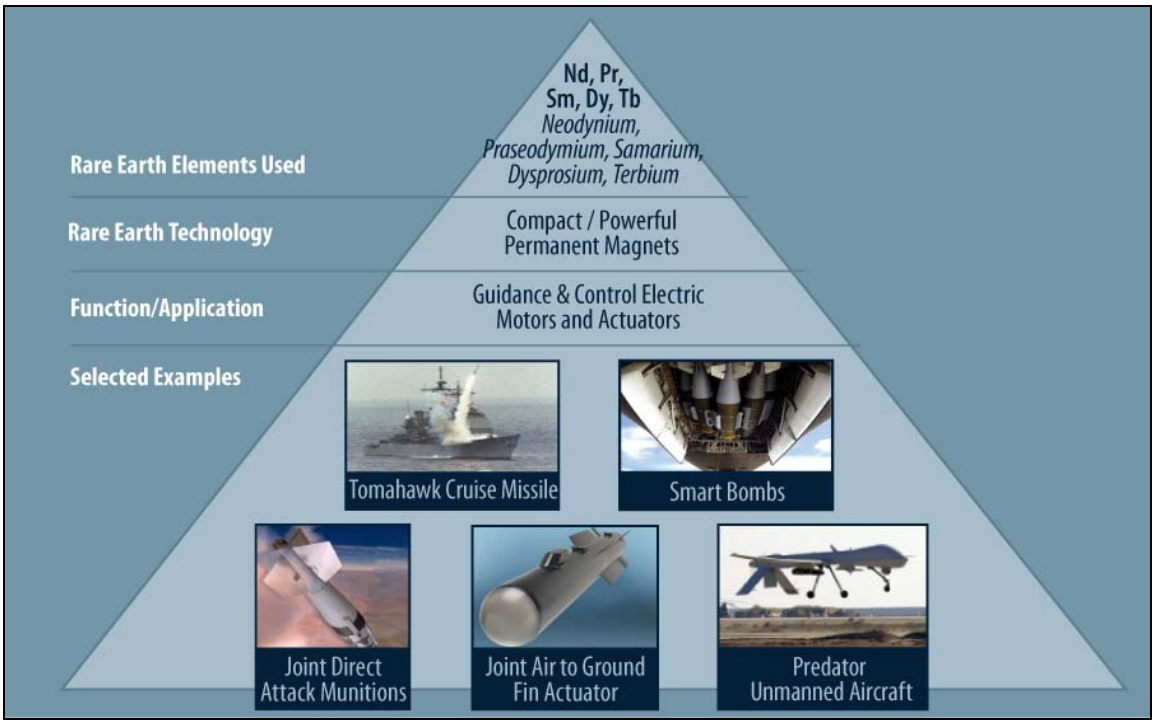
DOD estimates that the United States uses about 5% of the world's production of rare earths for defense purposes.[2] Rare earth elements are found in two types of commercially available, permanent magnet materials. They are samarium cobalt (SmCo), and neodymium iron boron (NdFeB). NdFeB magnets, considered the world's strongest permanent magnets, dominate rare earth magnet usage for defense and are essential to many military weapons systems. SmCo retains its magnetic strength at elevated temperatures and is ideal for military technologies such as precision-guided missiles, smart bombs, and aircraft. The superior strength of NdFeB allows for the use of smaller and lighter magnets in defense weapon systems.

The following illustrations (Figures 1-5) show the use of rare earth elements in a variety of defense-related applications:

- fin actuators in missile guidance and control systems, controlling the direction of the missile;
- disk drive motors installed in aircraft, tanks, missile systems, and command and control centers;
- lasers for enemy mine detection, interrogators, underwater mines, and countermeasures;
- satellite communications, radar, and sonar on submarines and surface ships; and
- optical equipment and speakers.

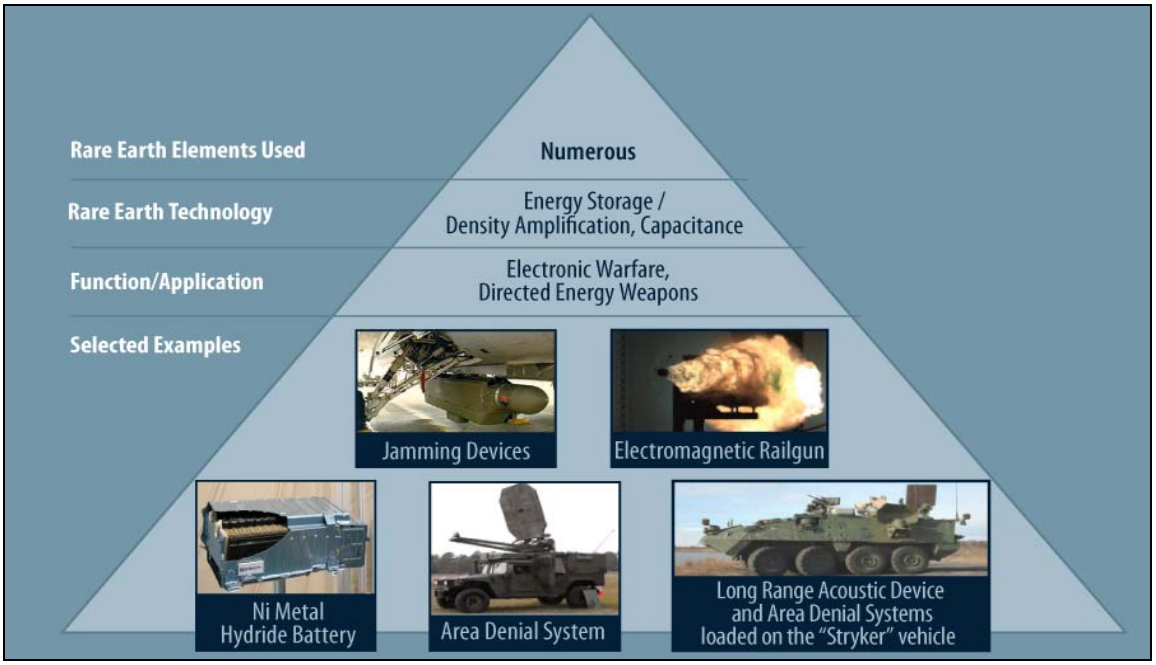
[2] Gopal Ratnam, "Pentagon is 'Myopic' over China's Rare Earths Monopoly, U.S. Lawmaker Says" *Bloomberg*, November 1, 2010, http://www.bloomberg.com/news/2010-11-01/pentagon-is-myopic-over-china-s-rare-earths-monopoly-u-s-lawmaker-says.html.

Figure 1. Rare Earth Elements in Guidance and Control Systems



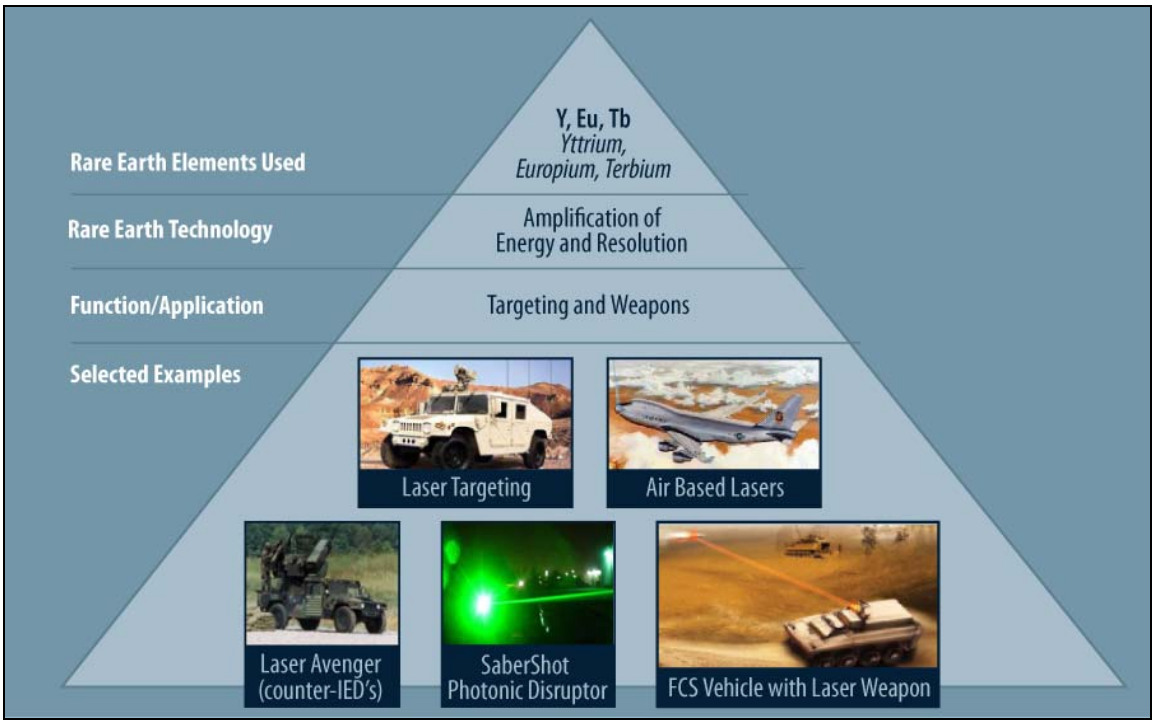
Source: Compiled from presentations by the Rare Earth Industry and Technology Association, the United States Magnet Manufacturing Association, and David Pineault, "Global Rare Earth Element Review," Defense National Stockpile Center, spring 2010.

Figure 2. Rare Earth Elements in Defense Electronic Warfare



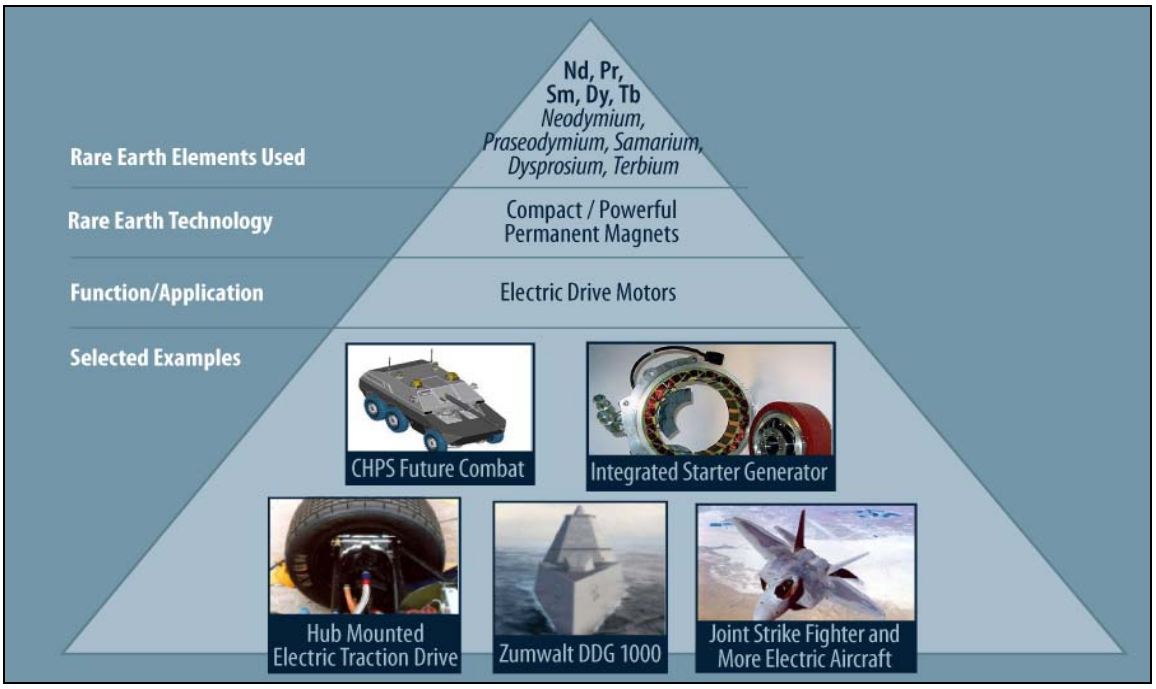
Source: Compiled from presentations by the Rare Earth Industry and Technology Association, the United States Magnet Manufacturing Association, and David Pineault, "Global Rare Earth Element Review," Defense National Stockpile Center, spring 2010.

Figure 3. Rare Earth Elements in Targeting and Weapon Systems



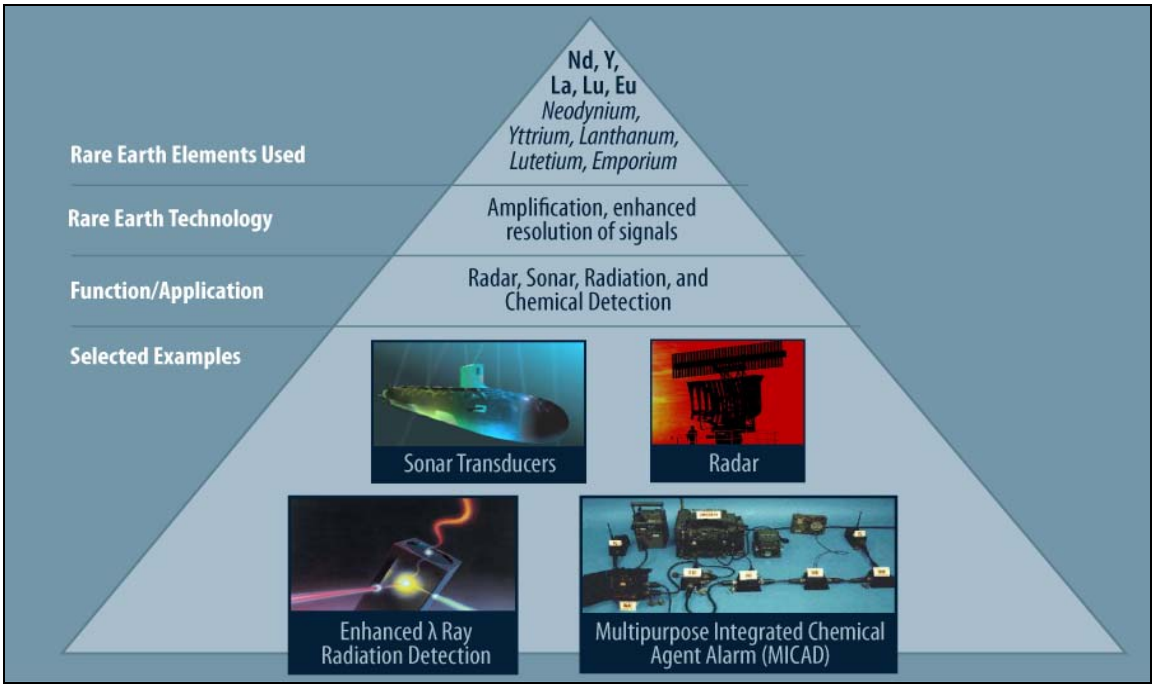
Source: Compiled from presentations by the Rare Earth Industry and Technology Association, the United States Magnet Manufacturing Association, and David Pineault, "Global Rare Earth Element Review," Defense National Stockpile Center, spring 2010.

Figure 4. Rare Earth Elements in Electric Motors



Source: Compiled from presentations by the Rare Earth Industry and Technology Association, the United States Magnet Manufacturing Association, and David Pineault, "Global Rare Earth Element Review," Defense National Stockpile Center, spring 2010.

Figure 5. Rare Earth Elements and Communication



Source: Compiled from presentations by the Rare Earth Industry and Technology Association, the United States Magnet Manufacturing Association, and David Pineault, "Global Rare Earth Element Review," Defense National Stockpile Center, spring 2010.

How and Where Are Rare Earths Produced?[3]

In April 2010, GAO reported on the world's production of rare earths and stated that China produced

- 97% of rare earth ore;
- 97% of rare earth oxides;
- 89% of rare earth alloys;
- 75% of neodymium iron boron magnets (NeFeB); and
- 60% of samarium cobalt magnets (SmCo).

The rare earth production process is complex and expensive. The stages of production consist of mining, separating, refining, alloying, and manufacturing rare earths into end-use items and components, as described in the GAO report.[4]

- The first stage is the actual mining where the ore is taken out of the ground from the mineral deposits.
- The second stage is separating the ore into individual rare earth oxides.[5]
- The third stage is refining the rare earth oxides into metals with different purity levels; oxides can be dried, stored, and shipped for further processing into metals.
- The fourth stage is forming the metals, which can be processed into rare earth alloys.
- The fifth stage is manufacturing the alloys into devices and components, such as permanent magnets.

From the 1960 to the 1980s, the United States was the leader in global production of rare earths and in the research and development of high-performance magnets.[6] Since that time, as discussed above, production has shifted primarily to China, due to lower labor costs and lower environmental standards. China is the only exporter of commercial quantities of rare earth metals.[7]

Today, the United States almost entirely lacks the refining, fabricating, metal-making, alloying, and magnet manufacturing capacity to process rare earths. One U.S. company, Electron Energy Corporation (EEC) in Landisville, PA, produces SmCo permanent magnets. EEC, in its production of SmCo permanent magnets, uses predominately samarium metal and significant amounts of gadolinium, rare earths for which there is no U.S. production. Additional rare earth

[3] For a more-detailed discussion of the supply chain issues, economics, and global supply of rare earths, see CRS Report R41347, *Rare Earth Elements: The Global Supply Chain*, by Marc Humphries.

[4] U.S. Government Accountability Office (GAO), *Rare Earth Materials in the Defense Supply Chain*, GAO-10-617R, April 14, 2010, p. 19, http://www.gao.gov/new.items/d10617r.pdf.

[5] The second stage creates a rare earth concentrate that is then separated through a flotation separation process into oxide. This process is referred to as beneficiation.

[6] Cindy Hurst, "China's Ace in the Hole: Rare Earth Elements," *Joint Forces Quarterly*, Issue 59, 4th Quarter, 2010, http://www.ndu.edu/press/lib/images/jfq-59/JFQ59_121-126_Hurst.pdf.

[7] Japan produces some rare earth metal for the production of alloys and magnets for its own use.

elements needed to produce rare earth magnets such as NeFeB include small amounts of dysprosium and possibly terbium. Currently, dysprosium and terbium are only available from China. EEC also imports metals for its magnet production from China through North American distributors and processes them into alloys in the United States before further processing into sintered SmCo magnets.[8] Also, Santoku America, Inc., the North American subsidiary of a Japanese company, with a production facility in Tolleson, AZ, processes both NdFeB and SmCo alloys used in the production of permanent magnets. Santoku America is the only U.S. producer of NdFeB alloys.[9]

Are Rare Earths Critical Materials for U.S. Defense?

There are several definitions of what constitutes a strategic or critical material; however, there is disagreement over what elements fall within these categories. Generally, strategic and critical materials have been associated with national security purposes. Some experts trace the first mention of strategic and critical materials to legislative language contained in both the Naval Appropriations Act of 1938 and the Strategic and Critical Materials Stockpiling Act of 1939 (P.L. 76-117, 50 U.S.C. 98 et seq.), which authorized the development of an inventory of strategic and critical materials for military use and provided funds for their purchase.[10]

DOD's current position on strategic materials was largely determined by the findings of the Strategic Materials Protection Board (SMPB).[11] The purpose of the SMPB was to determine the need to provide a long-term domestic supply of strategic materials designated as critical to national security, and to analyze the risk associated with each material and the effect on national defense that not having a domestic supply source might pose. The SMPB was to meet as determined to be necessary by the Secretary of Defense, but not less frequently than once every two years. SMPB's last report was issued in December 2008. Given the two-year meeting requirement, the board would have met in December 2010, but no meeting was held.

In the December 2008 report, the SMPB defined critical materials in this way: "the criticality of a material is a function of its importance in DOD applications, the extent to which DOD actions are required to shape and sustain the market, and the impact and likelihood of supply disruption."[12] Based on DOD's definition for "critical material," the 2008 SMPD report defined one rare earth element, beryllium, as a "strategic material critical to national security." The SPMB offered the following justification:

> High purity beryllium is essential for important defense systems, and it is unique in the function it performs. High purity beryllium possesses unique properties that make it indispensable in many of today's critical U.S. defense systems, including sensors, missiles

[8] Confirmed on March 17, 2011, by Peter C. Dent, Vice President for Business Development, Electron Energy Corporation.

[9] Santoku America is owned by Santoku Corporation (STC) of Kobe, Japan.

[10] National Research Council, *Managing Materials for a Twenty-first Century Military, and Minerals, Critical Materials, and the U.S. Economy*, http://books.nap.edu/catalog.php?record_id=12028#toc.

[11] The board was established through Section 843 of the John Warner National Defense Authorization Act for Fiscal Year 2007 (P.L. 109-364).

[12] Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, *Report of the Strategic Materials Protection Board*, December 12, 2008, http://www.acq.osd.mil/ip/docs/report_from_2nd_mtg_of_smpb_12-2008.pdf.

> and satellites, avionics, and nuclear weapons. The Department of Defense dominates the market for high purity beryllium and its active and full involvement is necessary to sustain and shape the strategic direction of the market. There is a significant risk of supply disruption. Without DOD involvement and support, U.S. industry would not be able to provide the material for defense applications. There are no reliable foreign suppliers that could provide high purity beryllium to the Department. Recognizing that high purity beryllium meets all the conditions for being a critical material, the Department should take, and has taken, special action to maintain a domestic supply. The Department has used the authorities of Title III of the Defense Production Act to contract with U.S. firm Brush-Wellman, Inc. to build and operate a new high purity beryllium production plant. [13]

The House Armed Services Committee criticized this definition, as discussed in the following excerpt that appeared in the House report accompanying H.R. 2647, the FY2010 National Defense Authorization Act.[14]

> This definition limits the purview of the Board to only those materials for which the determinations the Board is tasked to make are presupposed in the definition of the materials themselves. Furthermore, such a definition fails to include a range of materials that Congress has designated as critical to national security and, as such, has provided significant protection or domestic preference in DOD policy and in statute. For example, Congress has determined that reliance on foreign sources of supply for materials such as titanium, specialty steel, and high performance magnets, poses a heightened risk. The Board's narrowing of the definition of materials critical to national security renders the Board unable to provide perspective on the adequacy, suitability, or effectiveness of those policies. Moreover, it limits the ability of the Board to consider any course of action, however minor, in relation to a material until the point at which potential damage to national security is imminent and severe. It also creates the perverse situation that a material could be critical to every element of the industrial base upon which the Department depends, but not considered critical to the Department itself if the material is also used significantly in commercial items. As an indication of the inadequacy of this definition for the Board's functioning, the Board currently identifies only one material as meeting the definition for consideration as a strategic material critical to national security. The committee does not find this conclusion to be plausible and expects that the Board will swiftly revisit this definition to ensure that it is able to identify gaps in our domestic defense supply chain and provide the President, the Secretary of Defense, and Congress with information, analysis, and advice on strategic materials which are critical to the operations of the Department of Defense.

Congress has addressed this issue in the FY2011 National Defense Authorization Act (P.L. 111-383, H.R. 6523), where strategic materials are defined as "material essential for military equipment, unique in the function it performs, and for which there are no viable alternatives."

Policy Issues for Congress

Some Members of Congress have expressed concern with the nearly total U.S. dependence on foreign sources for rare earth elements. Some in Congress have raised questions about China's near dominance of this industry and the implications for U.S. national security. Yet the "crisis" for many policymakers is not the fact that China has cut its rare earth exports and appears to be

[13] Ibid, p. 6.

[14] U.S. Congress, House Armed Services Committee, H.Rept. 111-166, *Report on H.R. 2647: National Defense Authorization Act for Fiscal Year 2010*, P.L. 111-84, signed into law on October 28, 2009.

restricting the world's access to rare earths, but the fact that the United States has lost its domestic capacity to produce strategic and critical materials and that the manufacturing supply chain for rare earths has largely migrated to outside the United States. Still others are concerned about the impact of availability for defense systems. Additionally, some Members of Congress have questioned the lack of knowledge of what specific materials are needed for defense purposes, which materials are strategic and critical to national security, and what steps might be taken to increase the domestic capability to produce these materials.

In January 2011, three Members of Congress wrote a letter to Secretary of Defense Robert M. Gates outlining their concerns over what they perceived as a lack of action on DOD's part to ensure that adequate supplies of rare earths were available. They pressed for DOD to take immediate action, as described in excerpts below.

> Clearly, rare earth supply limitations present a serious vulnerability to our national security. Yet early indications are the DOD has dismissed the severity of the situation to date. Based on initial discussions with the DOD Office of Industrial Policy, we understand the effort to precisely ascertain and fully comprehend DOD consumption of certain rare earth elements is still an ongoing effort. In our view, it is a fundamental responsibility of DOD Industrial Policy to have a comprehensive understanding of the security of our defense supply chain, which requires understanding detailed knowledge of the sources and types of components and materials found in our weapon systems.
>
> As the ultimate customer, the Department has the right and responsibility to require their contractors to provide a detailed accounting of the various rare earth containing components within their weapon systems. This information should then be aggregated into an element by element overall demand for DOD. With that knowledge, DOD could compare expected supply and demand of each rare earth element with overall consumption by the Department to identify critical vulnerabilities in our supply chain. This will enable the Department to establish policies to ensure the defense supply chain has access to those materials. For example, one policy may be for the DOD to establish a limited stockpile of rare earth alloys that are in danger of supply interruption to ensure security of supply of both metals and magnets. [15]

Lack of Domestic Production Capacity in Rare Earths

Currently, the United States has only one rare earth mine production facility that is restarting production. However, the lack of a U.S. production capacity in rare earths will persist for the next one to two years. Molycorp, a U.S. company with a mining operation in Mountain Pass, CA, has recently announced plans to resume production after a 10-year break. Molycorp operates a separation plant at Mountain Pass, CA, and sells the rare earth concentrates and refined products from previously mined above-ground stocks. As previously mentioned, Molycorp has secured the final permits needed to construct a rare earth manufacturing facility, which is scheduled to open in 2012.[16] On January 24, 2011, Molycorp's board of directors announced the approval of an expansion plan that is expected to give Molycorp the ability to produce at an annual rate of up to

[15] U.S. Congress. Letter to Secretary of Defense Robert M. Gates, from Senator Mark Begich, Senator Lisa Murkowski, and Representative Mike Coffman, January 28, 2011. The letter can be viewed at http://www.politico.com/static/PPM110_110131_rare_earth.html.

[16] "Molycorp Secures Last of Permits Needed for Construction Start of $531 Million Rare Earth Manufacturing Supply Chain Project," *Business Wire*, December 31, 2010, http://www.businesswire.com/news/home/20101213005938/en/Molycorp-Secures-Permits-Needed-Construction-Start-531.

approximately 40,000 metric tons of rare earth oxide (REO) equivalent per year by the end of 2013.[17] The company expects that by 2012, the Mountain Pass mine will be able to achieve full-scale production of mining and separating the rare earth elements cerium, lanthanum, praseodymium, and neodymium. However, the Mountain Pass mine will not immediately be able to refine rare earth oxides into rare earth metals.

Some rare earth experts are concerned that DOD is not doing enough to mitigate the risk posed by a scarcity of domestic suppliers. Many trade associations are pursuing strategies to raise awareness about what some view as an impending rare earth crisis. Two such associations are the Rare Earth Industry and Technology Association (REITA), a consortium of academic and industry experts,[18] and the United States Magnetic Materials Association (USMMA), a coalition of magnet producers, representing aerospace, medical, and electronic materials, who provide critical technologies for defense weapon systems. [19] In February 2010, the USMMA unveiled a six-point plan to address the "impending rare earth crisis," which it asserts poses a significant threat to the economy and national security of the United States. The six-point plan advocates the formation of an interagency working group with the purpose of restoring a domestic rare earth supply chain.[20]

Possible Foreign Supply Chain Disruptions

Some Members of Congress are concerned that disruptions in the global supply chain for rare earths could result in a failure to meet projected needs for these elements in defense-related production and a possible rise in rare earth costs. GAO and the U. S. Department of Energy have examined these issues.

GAO Report on the Rare Earth Supply Chain

In response to congressionally directed requirements in Section 843 of the National Defense Authorization Act of 2010 (P.L. 111-84), GAO examined the rare earth supply chain issues. An April 2010 GAO report addressed the lack of U.S. presence in the global supply chain at each of the five stages of rare earth production—mining, separating, refining oxides into metal, fabricating of alloys, and the manufacturing of magnets and other components. GAO concluded that the United States lacks a domestic rare earth supply chain and offered the following assessment of the current defense rare earth supply:

[17] "Molycorp Announces Approval of Phase 2 Expansion at Mountain Pass, a Proposed Mandatory Convertible Preferred Offering by the Company and Proposed Secondary Offering of Common Stock," *Business Wire*, January 24, 2011, http://www.businesswire.com/news/home/20110124006068/en/Molycorp-Announces-Approval-Phase-2-Expansion-Mountain.

[18] See http://www.reitausa.org/renewable-energy-news/.

[19] United States Magnet Material Association, "Magnet Material Supply Chain Players Propose a Six-Point Plan to Address Impending Rare Earth Crisis," February 4, 2010, http://www.usmagnetmaterials.com/press-releases/Six-Point-Plan-Letter-2-04-10.pdf.

[20] "Magnet Materials Supply Chain Players Propose Six-Point Plan to Address Impending Rare Earth Crisis," *Vertical News*, February 19, 2010. This article may be viewed at http://mining-and-minerals.verticalnews.com/articles/3201615.html.

- While rare earth ore deposits are geographically diverse, current capabilities to process rare earth metals into finished materials are limited mostly to Chinese sources.

- The United States previously performed all stages of the rare earth material supply chain, but now most rare earth materials processing is performed in China, giving it a dominant position that could affect worldwide supply and prices.

- Based on industry estimates, rebuilding a U.S. rare earth supply chain may take up to 15 years and is dependent on several factors, including securing capital investments in processing infrastructure, developing new technologies, and acquiring patents, which are currently held by international companies.[21]

GAO was unable to determine whether DOD faces any supply chain vulnerability issues or the degree to which national security interests are potentially threatened by the current rare earth situation. Its assessment was limited, primarily because DOD stated that it was in the process of performing its own assessment and had not yet identified national security risks or taken steps to address any material shortages. DOD reported that its study would be completed by the end of September 2010. As of March 2011, the study has yet to be completed and released to the public.[22]

Annual Industrial Capabilities Report to Congress

Section 2504 of Title 10, United States Code, requires that the Secretary of Defense submit an annual report on industrial capabilities to the Committee on Armed Services of the Senate and the Committee on Armed Services of the House of Representatives. The 2009 report did not address the rare earth supply, but it did suggest that the issue warranted further study, as described in excerpts from the report.

> The lessons learned from the pre-slowdown economy will concentrate a global push for fuel efficiency and finding substitutes for hydrocarbon fuel products. This will drive up the demand for specialty metals and super alloys that are closely associated to battery manufacturing. These metals are typically not mined or melted within the United States and the E.U. countries. Therefore, this will likely become a growing strategic concern for the United States as resources will have to be utilized to secure the free flowing access to the limited supply of super alloys and specialty metals products (i.e., chromium, cobalt, lithium, rare earth and platinum group metals).[23]

[21] U.S. Government Accountability Office (GAO), *Rare Earth Materials in the Defense Supply Chain*, GAO-10-617R, April 14, 2010, at http://www.gao.gov/new.items/d10617r.pdf.

[22] Unnamed sources have reported in the press that the DOD study concludes that China's dominance over rare earths does not pose a national security issue for the United States. However, it is reported, the study goes on to say that defense suppliers report that neither defense contractors nor federal agencies currently track statistics for the quantities of rare earths used in defense weapon systems. Gopal Ratnam, "Pentagon Sees No Rare Earths Crisis: May Aid U.S. Producers," *Bloomberg News*, October 31, 2010, at http://www.businessweek.com/news/2010-10-31/pentagon-sees-no-rare-earths-crisis-may-aid-u-s-producers.html.

[23] U.S. Department of Defense (DOD), Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, Annual Industrial Capabilities Report to Congress, May 2010, p. 19, http://www.acq.osd.mil/ip/docs/annual_ind_cap_rpt_to_gress, congress-2010.pdf.

U.S. Department of Energy Report on Critical Mineral Strategy

In December 2010, the U.S. Department of Energy released a report that examined the role of rare earths in renewable energy technologies. While the report did not focus on the use of rare earths for national security and defense purposes, it does shed light on the steps DOD has undertaken to review the rare earth supply chain, as described in excerpts below.

> Recognizing the evolution of the market for rare earth elements (REEs), in the summer of 2009 the Office of Industrial Policy/AT&L, Department of Defense (DOD) self-initiated a review of the U.S. supply chain. The study is based on available forecasts and data from multiple sources and as a result, most of the data are available only at the aggregate level of all REE [Rare earth elements]. The study reviews the U.S. supply chain for both commercial and defense demand of REE. The study also assesses gaps in the supply chain and their potential implications for the Department.
>
> The rationale for this effort included the U.S. dependence on a sole supplier that is not domestic, the importance of REE in certain defense applications and forecasts for a surge in demand for commercial end uses that could strain global supplies. Recent events in the global market for REE have reinforced the Department's concern regarding reliable and secure supplies of REE.[24]

Coordination of the Federal Approach to Rare Earths

Different jurisdictional needs complicate a cohesive federal approach to rare earth supply chain policies. There is no unified opinion on whether every rare earth element is considered "critical," "strategic," or necessary for economic or national security purposes. Rare earth elements fall outside the scope of the Specialty Metal Clause, which restricts DOD from acquiring selected items unless they are wholly produced in the United States or nations covered by a Memorandum of Understanding.[25]

Working with the Department of Energy, in 2008 the White House Office of Science and Technology Policy (OSTP) convened an interagency group on rare earth elements. This group of subject-matter experts from various federal agencies discussed the potential usefulness of the White House taking a lead role on rare earth strategy.[26] Additionally, OSTP's National Science of Technology Council has formed a Critical Minerals Council.[27]

[24] U.S. Department of Energy, *Report on Critical Materials Strategy*, December 2010, pp. 58-59, http://www.energy.gov/news/documents/criticalmaterialsstrategy.pdf.

[25] For background on the Berry Amendment and the Specialty Metal Clause, see CRS Report RL31236, *The Berry Amendment: Requiring Defense Procurement to Come from Domestic Sources*, by Valerie Bailey Grasso.

[26] U.S. Congress, House Committee on Science and Technology, Subcommittee on Investigations and Oversight, hearing on Rare Earth Minerals and 21st Century Industry, March 16, 2010, http://democrats.science.house.gov/Media/File/Commdocs/hearings/2010/Oversight/16mar/Hearing_Charter.pdf.

[27] NSTC Executive Order, posted January 26, 2010, at http://www.whitehouse.gov/search/site/%22critical%20materials%22?filters=im_og_gid:7967.

Absence of the Study of Rare Earth Application Sciences in U.S. Colleges and Universities

There is a growing gap between the United States and China with regard to the academic study of rare earth elements. Rare earth chemistry and rare earth application sciences are rarely offered in U.S. colleges and universities today, while China employs thousands of scientists in both disciplines. The only U.S. public university with a rare earths specialty is the Colorado School of Mines, a public research university devoted to engineering and applied science. The decline in the U.S. manufacturing base could divert engineers, metallurgists, and scientists who might pursue careers in manufacturing into other fields of employment.

In a hearing before the House Committee on Science and Technology, Subcommittee on Investigations and Oversight, Dr. Stephan Freiman, a scientist and former member of the National Research Council's (NRC) Committee on Critical Mineral Impacts on the U.S. Economy, discussed the conclusions of a study sponsored by the NRC to examine the role of nonfuel minerals in the U.S. economy and potential material supply vulnerabilities.[28] Among the study's recommendations were the following:

> Federal agencies, including the National Science Foundation, Department of the Interior (including the USGS), Department of Defense, Department of Energy, and Department of Commerce, should develop and fund activities, including basic science and policy research, to encourage U.S. innovation in the area of critical minerals and materials and to enhance understanding of global mineral availability and use programs involving academic organizations, industry, and government to enhance education and applied research.

The study also recommended funding scientific research on the entire mineral life cycle and building cooperative programs among academia, industry, and government to enhance education and applied research.[29]

Options for Congress

Congress may consider both short-range and long-range options for securing a source for rare earth elements as part of its oversight role in addressing U.S. national security interests. Short-range options potentially include requiring DOD to release the rare earths report, convening defense suppliers to discuss rare earth material shortages, establishing rare earth material stockpiles for defense purposes, instituting a new critical minerals program, and reconvening the SMPB. Long-range options could include reducing DOD consumption of rare earth elements by identifying and securing equally effective alternatives to rare earths, establishing partnerships with foreign allies that could potentially offer a diversified source of foreign suppliers outside of

[28] NRC is the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine of the National Academies, chartered by Congress in 1863 to advise the government on matters of science and technology. See http://sites.nationalacademies.org/NRC/index.htm.

[29] Statement of Dr. Stephen Freiman, President, Freiman Consulting, Inc., Member, National Research Council Committee on Critical Mineral Impacts on the U.S. Economy, in U.S. House of Representatives, Committee on Science and Technology, Subcommittee on Investigations and Oversight, hearing on Rare Earth Minerals and 21st Century Industry, March 26, 2010, http://democrats.science.house.gov/Media/File/Commdocs/hearings/2010/Oversight/16mar/Hearing_Charter.pdf.

China, and providing more financial assistance for rare earth production within the United States. Each of these potential options is discussed below.

Congressional insight on these potential actions will largely depend on the findings and conclusions reached in DOD's long-overdue self-assessment on the defense rare earth supply chain. However, it is not clear if or when DOD will release its report.

Require DOD to Immediately Release the Rare Earths Report and Conduct Hearings on the Report

Congress could require DOD to immediately release the rare earths report, hold public hearings on its findings, and examine the methodology and assumptions used in collecting the data. DOD had reported to GAO that DOD's assessment of the defense supply chain would be released in September 2010. As of March 2011, the report has not been released. The reasons for the delay are uncertain. One press report stated that at least one Member of Congress was initially provided a briefing on the report and disagreed with its conclusion, reportedly, that China's monopoly on rare earth materials did not pose a national security threat.[30]

Convene Defense Suppliers to Discuss Supply Chain Issues

Congress could meet with defense suppliers, at all tiers of the supply chain, to ascertain their knowledge of material shortages and bottlenecks. While DOD purchases the end product (the weapons system) from prime contractors and relies on prime contractors to deliver the finished product, rare earth elements are important throughout the supply chain from the prime contractor through successive subcontractor tiers. Some contractors at lower ends of the tiers may be reluctant to signal to DOD that there are supply chain issues or challenges.

An issue that warrants further understanding is where there is convergence between the rare earth value supply chain and the defense supply chain. The rare earth supply chain starts with mining, flows from ore to concentrate, to oxide, to metal, to alloy, and then to the finished product, the magnet. In contrast, the defense supply chain starts with the prime contractor and moves through a successive number of subcontractors down to the ultimate "first line processor" who purchases a rare earth, value-added product such as metal, alloy, or permanent magnets for incorporation into a defense component.

Convene the Strategic Materials Protection Board

Congress could require DOD to convene the Strategic Materials Protection Board (SMPB). In its December 2008 report, as discussed above, the SMPB defined critical materials in this way: "the criticality of a material is a function of its importance in DOD applications, the extent to which DOD actions are required to shape and sustain the market, and the impact and likelihood of supply disruption."[31] As a result, the SMPB defined only one rare earth element, beryllium, as a

[30] Gopal Ratnam, "Pentagon is 'Myopic' Over China's Rare Earths Monopoly, U.S. Lawmaker Says," *Bloomberg News*, November 1, 2010 , http://www.bloomberg.com/news/print/2010-11-01/pentagon-is-myopic-over-china-s-rare-earths-monopoly-u-s-lawmaker-says.html.

[31] Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, Report of the Strategic (continued...)

"strategic material critical to national security." Congress may convene the board because the present board might determine that some rare earth elements have moved into a position where they are now more critical to national security purposes. The next SMPB might determine that some rare earth elements have moved into a position where they are now more critical to national security.

Congress might demand the 2010 statutorily required meeting of the board to commence immediately. The next SMPB will be required to use the new definition of "materials critical to national security" as defined in Section 829 of the FY2011 NDAA, which states the following:

> Sec. 829. Definition of Materials Critical To National Security
>
> (1) The term "materials critical to national security" means materials (A) upon which the production or sustainment of military equipment is dependent; and (B) the supply of which could be restricted by actions or events outside the control of the Government of the United States.[32]

In the short-run, however, creating a stockpile could raise prices even further because of the increased demand.

Require Stockpiling of Specific Materials

Congress could require a strategic rare earth elements stockpile. Stockpiles might possibly increase the security of the domestic U.S. supply for rare earths. Congress may consider compiling a "virtual" stockpile database, with commitments and contracts with suppliers to buy the items when needed. One trade association, USMMA, advocates for a limited strategic reserve of rare earth alloys, metals, and magnets. USMMA asserts that government action is needed to ensure that there is a downstream domestic manufacturing capability.

> This strategic stockpile would ensure our Department of Defense has ready access to those materials needed to ensure our national security and to incentivize the return of domestic manufacturing. With defense critical materials such as dysprosium being sourced solely from China, it is critical that the Department of Defense have access to rare earth oxides from reliable producers and manufacturers in the United States and ally nations to perform value added processes, such as metal, alloy and magnet manufacturing.[33]

Fund the Downstream Supply Capacity

Once DOD and its suppliers identify whether and where material shortfalls exist, Congress could determine which stages of the supply chain (e.g., mining or manufacturing) require federal funding.

(...continued)

Materials Protection Board, December 12, 2008.

[32] P.L. 111-383, Section 829.

[33] "USMMA Calls For A Rare Earth Strategic Reserve," *Businesswire*, February 23, 2011, http://www.businesswire.com/news/home/20110223006331/en/USMMA-Calls-Rare-Earth-Strategic-Reserve.

Fund Rare Earth Research

With the growing strategic importance of rare earths, and in order to create interest and build additional U.S. leadership in rare earth research and development, Congress may consider funding rare earth application sciences in curriculums for military and other government institutes or in national research and development centers designed to train students, scientists, and engineers.

Institute a New Critical Minerals Program

Should DOD determine that rare earths fall into the classification of critical minerals, Congress could institute a new Critical Minerals Program. In the early 1980s, there existed a Critical Minerals Program aimed at warning Congress about potential supply shortages, protecting strategic materials, and keeping an inventory of those minerals on hand in order to mitigate a supply shock.[34] This program ended in the 1990s as the consensus within Congress grew that the market could handle mineral supply disruptions without government intervention. Two decades later, at a 2010 hearing of the House Science and Technology Committee on rare earths, one policymaker suggested that the time has come to revive the program:

> This is not the first time the Committee has been concerned with the competitive implications of materials such as rare earths. In 1980—30 years ago—this Committee established a national minerals and materials policy. One core element in that legislation was the call to support for "a vigorous, comprehensive and coordinated program of materials research and development."
>
> Unfortunately, over successive administrations, the effort to keep that program going fell apart. Now, it is time to ask whether we need to revive a coordinated effort to level the playing field in rare earths.
>
> In particular, I want to learn if there is a need for increased research and development to help address this Nation's rare earth shortage, or if we need to re-orient the research we already have underway.
>
> Based on my review of the written submissions, it appears that we could benefit from more research both in basic and applied materials sciences. [35]

[34] In the first session of the 99th Congress, the role of the Critical Minerals Program was the subject of a hearing before the House Committee on Science and Technology, Subcommittee on Transportation, Aviation, and Materials. At the hearing (held October 8-10, 1985), Robert N. Broadbent, Assistant Secretary for Water and Science, U.S. Department of the Interior, testified: "The Strategic and Critical Minerals Program of the U.S. Geological Survey provides a continuing assessment of the Nation's endowment of strategic minerals and a continuing analysis of the world's mineral resources for the formulation of national minerals policy and the identification of secure sources of minerals that are critical to the security, industrial production, and economic well-being of this country and that are vulnerable to disruption in supply"; http://www.ebooksread.com/authors-eng/aviation-united-states-congress-house-committee-on-scien/the-national-critical-materials-act-of-1984—hearings-before-the-subcommittee-o-tin/page-2-the-national-critical-materials-act-of-1984—hearings-before-the-subcommittee-o-tin.shtml. The testimony can also be viewed at http://www.archive.org/stream/nationalcritical00unit/nationalcritical00unit_djvu.txt.

[35] Statement of Bart Gordon, Chair, House Committee on Science and Technology, Subcommittee on Investigations and Oversight, Hearing on Rare Earth Minerals and the 21st Century Industry, March 16, 2010, http://sciencedems.house.gov/publications/OpeningStatement.aspx?OSID=2803.

Develop Partnerships with Allies to Diversify the Supply Source

Congress may encourage DOD to pursue joint ventures with other nations, as many other nations are seeking alternatives to a near total dependence on rare earths from China. These partnerships may take place at any stage of the supply chain. It is critical for DOD to consider the implications of sourcing utilized by these partner nations. For example, if DOD relies on a partner nation for rare earth metals, and that nation procures their oxides from China, this partnership may not provide the requisite security of supply.

Appendix. Legislative Activity

In the 111th Congress, two bills were enacted that contain provisions affecting rare earth policy. The first was P.L. 111-84 (H.R. 2647), the Ike Skelton National Defense Authorization Act for FY2010. Section 843 of P.L. 111-84 required the Government Accountability Office (GAO) to examine rare earths in the defense supply chain, and it also required the Secretary of Defense to assess the defense supply chain and develop a plan to address any shortfalls or other supply chain vulnerabilities.[36] The second bill was P.L. 111-383, the National Defense Authorization Act for Fiscal Year 2011, which contains a provision (Section 839) that requires the Secretary of Defense to undertake an assessment of the supply chain for rare earth materials and determine which, if any, rare earths are strategic or critical to national security and to develop a plan to address any supply chain vulnerabilities.[37]

In both the 111th and 112th Congresses, several bills were introduced that could affect rare earth policy. They are described below.

Legislation Introduced in the 112th Congress

H.R. 952, the Energy Critical Elements Renewal Act of 2011

On March 8, 2011, Representative Miller introduced the Energy Critical Elements Renewal Act of 2011. The bill was referred to the Committee on Science, Space, and Technology.

The bill would develop an energy critical elements program, amend the National Materials and Minerals Policy Research and Development Act of 1980, establish a temporary program for rare earth material revitalization, and serve other purposes.

S. 383, the Critical Minerals and Materials Promotion Act of 2011

On February 17, 2011, Representative Udall introduced the Critical Minerals and Materials Promotion Act of 2011. The bill was referred to the Committee on Energy and Natural Resources. The bill would require the Secretary of the Interior to establish a scientific research and analysis program to assess current and future critical mineral and materials supply chains, strengthen the domestic critical minerals and materials supply chain for clean energy technologies, strengthen education and training in mineral and material science and engineering for critical minerals and materials production, and establish a domestic policy to promote

> an adequate and stable supply of critical minerals and materials necessary to maintain national security, economic well-being, and industrial production with appropriate attention to a long-term balance between resource production, energy use, a healthy environment, natural resources conservation, and social needs.[38]

[36] P.L. 111-84 was signed into law on October 28, 2009.

[37] It should be pointed out that much of the language of the RESTART Act, proposed by Representative Coffman, was included as an amendment to the FY2011 National Defense Authorization Act, which was passed in the House on May 28, 2010, during the 111th Congress.

[38] S. 383, Section 6, Supply of Critical Minerals and Materials.

H.R. 618, the Rare Earths and Critical Materials Revitalization Act of 2011

On February 10, 2011, Representative Boswell introduced the Rare Earths and Critical Materials Revitalization Act of 2011.The bill was referred to the Committee on Science, Space, and Technology.

The bill seeks to develop a rare earth materials program and amend the National Materials and Minerals Policy, Research and Development Act of 1980. If enacted, it would provide for loan guarantees to revitalize domestic production of rare earths in the United States.

Legislation Introduced in the 111th Congress

H.R. 4866, the Rare Earth Supply Technology and Resources Transformation Act of 2010

On March 17, 2010, Representative Coffman introduced the Rare Earth Supply Technology and Resources Transformation Act of 2010 (RESTART). The bill was referred to three committees: the House Armed Services Committee, the House Ways and Means Subcommittee on Trade, and the House Financial Services Committee.

The bill sought to create a new interagency initiative on rare earth supply chain issues. H.R. 4866 would have established a federal government-wide interagency working group, at the Assistant Secretary level, from the Departments of Commerce, Defense, Energy, the Interior, and State, with participants from the U.S. Trade Representative (USTR) and White House Office of Science and Technology Policy. The working group would have assessed the rare earth supply chain to determine which rare earths were critical to national and economic security. Based on a critical designation, rare earth elements would have been stockpiled by the Defense Logistics Agency (DLA) as part of the National Defense Stockpile. The DLA would have made, if necessary, a commitment to purchase rare earth raw materials for processing and refining, including purchases from China. Stockpiling would have been terminated when the working group agencies determined that rare earths were no longer critical to U.S. national security or economic well-being.[39]

[39] The bill directs the Secretaries of Commerce, of Defense, of Energy, of the Interior, and of State to (1) appoint an Executive Agent, at the Assistant Secretary level, to serve as a representative on an interagency working group to reestablish a competitive domestic rare earth supply chain, and (2) assess and report to Congress on the chain, determining which rare earth elements are critical to national and economic security. It directs the United States Trade Representative (USTR) and the Office of Science and Technology Policy also to appoint representation to such working group. It requires the Secretary of Defense to commence procurement of critical rare earth materials and place them in a national stockpile, and the Defense Logistics Agency, Defense National Stockpile Center, to serve as administrator of the stockpile. It authorizes the administrator, if necessary to meet U.S. national security and economic needs, to purchase rare earth materials from the People's Republic of China. It instructs the USTR to (1) initiate and report to Congress on a comprehensive review of international trade practices in the rare earth materials market; or (2) initiate an action before the World Trade Organization (WTO) as a result of the review. It directs the Secretaries of Commerce, of the Interior, and of State to report to the domestic rare earth industry about mechanisms for obtaining government loan guarantees to reestablish a domestic rare earth supply chain. It directs the Secretaries of Defense and of Energy to issue guidance for the industry related to obtaining such loan guarantees. It expresses the sense of the Congress regarding a prioritization of Defense Production Act projects with respect to the domestic rare earth supply chain.

H.R. 6160, the Rare Earth and Critical Materials Revitalizations Act of 2010

On September 22, 2010, Representative Dahlkemper introduced the Rare Earth and Critical Materials Revitalizations Act of 2010. The bill sought to develop a rare earth materials program and amend the National Materials and Minerals Policy, Research and Development Act of 1980. If enacted, the bill would have provided for loan guarantees to revitalize domestic production of rare earths in the United States. The bill was passed by the House on September 29, 2010, and forwarded to the Senate Committee on Energy and Natural Resources.

S. 3521, the Rare Earth Supply Technology and Resources Transformation Act of 2010

S. 3521 was introduced by Senator Murkowski on June 22, 2010. Congress held a hearing on the bill before the Senate Committee on Energy and Natural Resources, Subcommittee on Energy, on September 30, 2010. The text of the bill offered a "Sense of the Congress" statement that

> (1) the United States faces a shortage of key rare earth materials that form the backbone of both the defense and energy supply chains; (2) the urgent need to reestablish a domestic rare earth supply chain warrants a statutory prioritization of projects to support such reestablishment; (3) there is a pressing need to support innovation, training, and workforce development in the domestic rare earth supply chain; and (4) the Departments of Energy, of the Interior, of Commerce, and of Defense should each provide funds to academic institutions, federal laboratories, and private entities for innovation, training, and workforce development in the domestic rare earth supply chain.

S. 4021, the Rare Earth Supply Technology and Resources Transformation Act of 2010

S. 4031 was introduced by then-Senator Evan Bayh on December 15, 2010, and referred to the Senate Committee on Energy and Natural Resources. The bill would have promoted exploration and development of a domestic supply of rare earths, and reestablished a U.S. competitive rare earth supply chain for rare earths in the United States and in the countries of foreign allies.

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