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THE UNDER SECRETARY OF DEFENSE
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ACQUISITION,
TECHNOLOGY
AND LOGISTICS

FEB 10 2014

The Honorable Carl Levin
Chairman
Committee on Armed Services
United States Senate
Washington, DC 20510

Dear Mr. Chairman:

The enclosed report responds to a request in House Report 113-102, accompanying the National Defense Authorization Act for Fiscal Year 2014. The report language requests the Under Secretary of Defense for Acquisition, Technology, and Logistics submit a report on the risk mitigation strategy used by the Department of Defense (DoD) for rare earth elements focusing on alternative sources of rare earth supply and on the reclamation of rare earths from waste.

The enclosed report finds that reclamation technologies for rare earth elements largely remain cost prohibitive under current conditions. DoD is actively monitoring material demand and supply, assessing risks, and considering the benefits and costs of all mitigation options to ensure a supply of rare earth materials.

Identical letters have been sent to other congressional defense committees.

Sincerely,

Frank Kendall

Enclosure:
As stated

cc:
The Honorable James M. Inhofe
Ranking Member

DIVERSIFICATION OF SUPPLY CHAIN AND RECLAMATION ACTIVITIES RELATED TO RARE EARTHS

Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics

February 2014

The estimated cost of this report or study for the Department of Defense is approximately $21,000 for the 2014 Fiscal Year. This includes $17,000 in expenses and $5,000 in DoD labor.
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Report to Congress on Diversification of Supply and Reclamation Activities Related to Rare Earth Elements

Executive Summary

This report has been prepared pursuant to House Report 113-102, page 296, to accompany H.R. 1960, the National Defense Authorization Act for Fiscal Year 2014. The House Report requires DoD to submit this report on the Department's earlier established risk mitigation strategy[1] for rare earths for U.S. defense demands, focusing on alternative sources of rare earth supply and in particular the reclamation of rare earths from waste.[2]

Overall, the Department's strategy in this area consists of four parts: (1) active monitoring of material demand and supply conditions; (2) structured risk assessments; (3) careful consideration of the benefits and costs of various risk mitigation options; and (4) a three-part risk mitigation strategy that includes diversification of supply, pursuit of substitutes, and reclamation of waste.[3] The constant, active monitoring of the global situation concerning rare earths is the first and very important part of this overall strategy, as is the regular assessment of risks to the DoD supply of rare earths under various planning cases and conditions. The last major parts of the overall strategy are structured consideration of actions to be taken to mitigate risks as the situation warrants, and selective DoD risk mitigating initiatives, as appropriate. Today, DoD is implementing all major parts of its strategy and remains ready to take further actions using particular mitigation options as needed.

The Department observes that market supply and demand conditions overall have significantly improved in the United States and internationally since the 2010 and 2011 turmoil in the rare earths markets.[4] As cited in this report, there has been a significant decrease in the demand and prices for rare earths, as well as an increase in the availability of supply, including material surpluses and diversification in production (e.g., re-opening of major rare earths mining operations and magnet production in the United States).

In addition to an 11.8-percent decline in the overall global demand for rare earths from 2010 to 2013,[5] earlier forecasted growth in demand through 2016 has been revised downward.[6] The

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[1] This strategy was developed by the Department of Defense pursuant to Section 843 of the National Defense Authorization Act for FY 2011 (P.L. 111-383) and Senate Report 111-201.

[2] For the purposes of this report, reclamation includes the recovery of material from end-of-life manufactured products that contain rare earth elements (e.g., magnets from old computer hard drives, phosphors from discarded light bulbs and batteries from consumer electronics) as well as recovering rare earths from tailings produced from earlier mining activities. While this report mentions opportunities that exist to reprocess rare earth containing scrap generated from producing new products (e.g., rare earth magnets) and the increased reuse of rare earth containing industrial manufacturing materials (e.g., rare earth based polishes), both areas of rare earths conservation were considered outside of the primary focus of House Report 113-102 on recovering rare earths from discarded waste materials and products.

[3] The Department also has additional risk mitigation authorities and mechanisms available (e.g., Strategic and Critical Materials Stock Piling Act and the Defense Production Act).

[4] *Annual Industrial Base Capabilities Report to Congress*, submitted by the Under Secretary of Defense for Acquisition, Technology and Logistics, Office of the Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy, October 2013.

[5] Curtin-IMCOA, *Rare Earths Quarterly Bulletin #5*, by Dudley J. Kingsnorth, June 2013.

Department of Defense projects almost no growth in U.S. defense demand for rare earths between 2015 and 2018.[7]

The Department observes that the supply of rare earths for U.S. defense acquisition programs is not presently being disrupted. The Department also estimates no shortfalls of rare earth supplies of ores and concentrates for U.S. defense demands through the 2015 to 2018 timeframe.[8]

With respect to rare earth reclamation, DoD evaluated the applications for which it uses rare earths and the potential for the recovery of rare earths from those applications at end-of-product-life (e.g., magnets, batteries, displays and light bulbs). The Department also evaluated the current potential for reclaiming rare earths from tailings of U.S. mining operations. However, many reclamation approaches are largely considered cost-prohibitive in the United States because of a variety of factors including, among others, technical challenges, economic barriers, and regulatory issues. Within the private sector, with the exception of the partial recovery of rare earths from phosphors contained in light bulbs, there are no commercial-scale rare earth recycling and reclamation operations in the United States, and limited operations of this kind exist outside the country.

Chiefly for these reasons, DoD does not currently see a compelling need to take programmatic action with respect to rare earth recycling and reclamation and indeed, because of the lack of a sufficient business case, the Department does not currently have any operational-level rare earth recycling and reclamation defense programs. Nevertheless, DoD continues to support selected promising rare earth materials research and assessment activities, including reclamation and recycling. Other U.S. Government agencies (e.g., the Department of Energy and the National Science Foundation) are doing the same, consistent with their missions.

Moving forward, and as a regular part of its larger strategy in this area, DoD continues to actively monitor rare earth markets, assess potential risks to its supply, and evaluate U.S. defense needs, risk mitigation options, and related DoD program requirements. Along these lines, in the last 3 years DoD conducted and reported to Congress on six separate assessments of various aspects of rare earth supply risk.[9] Those assessment efforts led the Department to undertake further risk mitigation measures. DoD remains prepared to take additional actions on its rare earth risk mitigation strategy as circumstances warrant. In the meantime, the U.S. defense industrial base is prepared to take advantage of future rare earth market opportunities as they arise (e.g., increased supply opportunities that may result from private sector progress in rare earths reclamation).

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[6] *The Global Rare Earths Industry: Poised for Growth*, by Dudley J. Kingsnorth, November 2012.

[7] Strategic and Critical Materials 2013 Report on Stockpile Requirements

[8] Supply shortfall assessments of U.S. defense demands for rare earth ores and concentrates for the period of 2015 through 2018 are reported in the *Strategic and Critical Materials 2013 Report on Stockpile Requirements* submitted to the Congress by the Department of Defense in January 2013. This report did estimate a U.S. defense shortfall for a specialty rare earth oxide used in lasers for certain weapon systems. To mitigate this estimated shortfall, DoD has recently been authorized by the Congress, in the FY14 NDAA, to create a stockpile of related materials. In addition, DoD is actively investigating the potential for re-using rare earth containing lasers from end-of-life of military equipment.

[9] Rare Earth Elements in National Defense: Background, Oversight Issues, and Options for Congress, by Valerie Bailey Grasso, September 17, 2013.

Introduction

This report has been prepared pursuant to House Report 113-102 that accompanied H.R. 1960, National Defense Authorization Act (NDAA) for Fiscal Year 2014 (See Appendix 1). The House Report requests the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)) to submit a report to the congressional defense committees by February 1, 2014, on the Department of Defense's risk mitigation strategy for rare earth elements as it pertains to U.S. defense demands. The House Report states its understanding that the Department intends to pursue a three-pronged strategy to secure supplies of rare earth elements, which consists of diversification of supply, pursuit of substitutes, and a focus on reclamation of waste, as part of a larger U.S. Government recycling effort. The House Report requests the Under Secretary's Report to answer several questions focused on alternative sources of rare earth supply from the reclamation of waste.

DoD Risk Mitigation Strategy for Rare Earth Elements

Due to a combination of reduced rare earth supplies from China coupled with a temporary sharp rise in demand for related materials in 2010-2011, the rare earth market was exhibiting large price spikes and showing some potential for shortages to occur within the United States, with respect to both raw materials and products containing rare earths. In the Ike Skelton National Defense Authorization Act for Fiscal Year 2011, Public Law 111-383, Congress required the Department to prepare a report on the supply and demand for rare earth materials in U.S. defense applications. In that report, DoD stated its risk mitigation strategy for rare earths.[10] That strategy, which DoD is currently pursuing, includes the aforementioned three-prongs: diversification of supply, pursuit of substitutes, and a focus on reclamation of waste as part of a larger U.S. Government recycling effort. Diversification means taking advantage of new sources of rare earths, including virgin material from new mines, materials and products from new factories, material saved via more efficient processing and manufacturing technologies (e.g., saving of rare earth containing manufacturing scrap), and material conserved via new product designs. Substitution means taking advantage of direct, material-for-material substitutes as well as functional substitutes—products that perform the same functions as products using rare earths but via different technical approaches. Reclamation of waste includes using rare earths recovered from mine tailings, recycled components post-consumer waste, and other waste streams such as those from industrial production of other materials.

The first part of the Department's strategy in this area consists of the constant, active monitoring of the global situation concerning rare earths, the assessment of its implications for the supply of rare earths to the defense industrial base, and the consideration of actions to be taken to mitigate risks as the situation warrants. DoD monitors the rare earth markets, to include the global supplies of and demands for materials and products. It assesses potential risks to the defense and essential civilian supply chains necessary to assure secure supplies of rare earths essential to national security. It also considers actions to take that include developing policy, contingency plans, and other instruments to ensure the availability of supply. These monitoring, assessing,

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[10] Under Secretary of Defense for Acquisition, Technology and Logistics, *Report to Congress, Rare Earth Materials in Defense Applications* (March 2012); see also Office of the Secretary of Defense, *Report to Congress on Assessment of Feasibility and Advisability of Establishment of Rare Earth Material Inventory* (September 2012).

and planning activities are carried out regularly by various offices within the Office of the Secretary of Defense and the Military Departments.

Although rare earth materials are widely used within the defense industrial base, such end uses represent a small fraction of total U.S. consumption. Therefore, as it does with most materials, DoD looks first to the market to mitigate rare earth supply risks. Indeed, the market has been responding to mitigate the risks that were seen at the time DoD stated its rare earth risk mitigation strategy (e.g. developing new and diverse sources of supply and reducing demand by developing substitutes and product designs that use less or no rare earth material). However, where conditions warrant, DoD takes direct action to mitigate such risks further. Such actions can include investing in assured production or materials processing capabilities, establishing secure inventories of materials or parts, and/or establishing additional qualified defense material suppliers.

There have been limited economic incentives within the marketplace to reclaim and recycle rare earths. Furthermore, because U.S. defense demand for rare earths is small relative to their estimated supply, DoD lacks the necessary requirements that would warrant programmatic actions (current or planned) to execute those aspects of its rare earth strategy for implementing commercial-scale reclamation of rare earths—including recycling of end-of-life products (e.g., electronic devices) and/or processing of rare earth containing tailings from earlier mining of minerals.

The basis for this decision is reflected in DoD's Strategic and Critical Materials 2013 Report on Stockpile Requirements that was coordinated by the Department and submitted to the Congress in January 2013. In that report the DoD evaluated Department-wide U.S. defense and essential civilian demands for rare earths (along with numerous other materials) for 2015 through 2018. For this purpose it assessed the availability of global rare earths supply in the context of a Congressionally-mandated, and large scale, national emergency that included major conflict scenarios and significant rare earths supply disruptions. Of the rare earth ores and concentrates assessed for the 2013 Report on Stockpile Requirements, there were no projected shortfalls estimated for U.S. defense purposes—including rare earths requirements for defense acquisition programs and the associated indirect demands for rare earths necessary to support the U.S. defense industrials base.[11] There was a special National Defense Stockpile (NDS) supply chain assessment for one "downstream" rare earth material that identified a shortfall for a very small amount of a high purity "heavy" rare earth oxide.[12]

In terms of peacetime U.S. defense demands for rare earths, and at the individual defense program level (e.g., individual weapon system), during the past few years there have been no major supply interruptions that have significantly disrupted DoD defense programs. Although DoD had noted reports of temporary price increases and possible tight inventories of some rare earth materials at the height of the rare earth market turmoil from late 2010 through 2011, there were no major supply disruptions to DoD's defense acquisition programs during this period.

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[11] The 2013 Report on Stockpile Requirements identified rare earth supply shortfalls for essential civilian demands during the report's 2015 - 2018 Base Case scenario: yttrium (1,899 MTs), scandium (572 MTs), erbium (124 MTs), dysprosium (47 MTs), thulium (20 MTs) and terbium (7 MTs).

[12] The 2013 Report on Stockpile Requirements also reported U.S. defense shortfalls for beryllium and several high performance carbon fibers .

Based on DoD's 2013 Report on Stockpile Requirements to the Congress and the fact that there is no evidence of major interruptions to the supply of rare earths that have disrupted current or recent defense acquisition programs, there are no U.S. defense requirements—currently or estimated over the next 5 years—that would warrant DoD initiating commercial-scale rare earth reclamation defense programs as a means to mitigate existing or anticipated rare earths shortfalls.

A decision by DoD to directly execute any of its rare earth supply risk mitigation strategies (i.e., traditional government stockpiling in addition to establishing U.S. defense specific programs in reclamation, substitution, and diversification of supply) would be driven by market (and geopolitical) supply and demand considerations—specifically, situations where U.S. defense industrial base requirements for rare earths could not be satisfied by the private sector as is done under current U.S. defense acquisition practices and industrial base conditions. Conditions that could lead to DoD undertaking extraordinary steps to intervene directly in private sector rare earth markets in support of U.S. defense needs include potential rare earth supply disruptions that would be severe and persistent enough to seriously affect DoD's defense acquisition programs and threaten serious harm to U.S. military capabilities.

To prepare for the unlikely event of a major interruption of the supply of rare earths for U.S. defense requirements (or other significant market developments that could seriously affect U.S. defense acquisition programs and military capabilities), DoD's contingency planning activities include comprehensive assessments of supply and demand, as well as ongoing evaluation of potential supply risks and mitigation options.

Recent Rare Earth Market Developments

Since DoD's initial rare earths report to the Congress in 2011,[13] market conditions—reflected by an increase in supply and a decrease in demand—have significantly improved[14] for consumers of rare earths, including suppliers within the U.S. defense industrial base. Improvements in the supply of rare earths that have benefited consumers include the largest and most commonly used rare earths: light and medium rare earth elements including those used to produce catalysts, polishing powders, glass, batteries, and magnets. There have also been relative improvements in the availability of much less commonly used (albeit still very important) heavy rare earth elements including those used mainly in the production of phosphors for lighting products and displays, as well as those used in smaller quantities as additives within a variety of specialized materials including crystals for lasers, dopants in magnet alloys, and stabilizers for high temperature jet engine component coatings and ceramics for fuel cells.

Examples of significant market changes that have benefited consumers of rare earth materials since late 2010 and mid 2011 include:

- Prices for basic rare earth materials (e.g., compounds) have fallen significantly since their historic highs of the last 2 to 3 years—including the most widely used light and medium rare earth elements as well as less used heavy rare earths.

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[13] Interim Report, Assessment and Plan for Critical Rare Earth Materials in Defense Applications, from USD (AT&L) to the Congress, August 2011.

[14] *The Global Rare Earths Industry: Poised for Growth*, by Dudley J. Kingsnorth, November 2012.

- The available supply of rare earths has significantly improved for the most commonly used rare earth elements (including those used to produce catalysts, batteries, polishing material, glass and magnets). In some cases, the most widely used rare earths are deemed by producers to be in surplus.[15] The available supply of even less commonly used rare earths—specifically heavy rare earths—has also improved during the past few years.

- There have been significant supply side improvements in global rare earth markets that have further benefited consumers, including a number of very positive private sector developments in North America. Most significant has been U.S.-based Molycorp's recently re-opened Mt. Pass rare earth mine and processing plant in California (with a total rare earth element oxide annual production capacity of 19,050 metric tons). The company has continued to expand and diversify its other rare earth production capabilities in the United States and internationally. Actions include acquisitions, joint ventures, and other key supplier arrangements throughout rare earth supply chains in Asia, Europe, and North America.

- Another very significant supply side development for U.S. buyers and consumers of rare earths involves a recent rare earth magnet production plant opening in the United States, a plant owned by the Japanese-based firm Hitachi. This new manufacturing facility in North Carolina has production capacity and capabilities to produce large quantities (relative to the needs of the defense industrial base) and diverse grades of high-performance, sintered Neodymium Iron Boron (NdFeB) rare earth magnets. In addition to this new U.S. plant's ability to support important U.S. commercial and industrial market demands for sintered NdFeB magnets, the facility could serve as a key supplier within DoD's U.S. defense industrial base.

- Other positive rare earths supply side developments underway in North America include the ongoing exploration and development of several new rare earth mining and processing ventures in the United States and Canada, including potential possibilities to produce rare earths in the future from tailings generated from earlier mining operations.

- In addition to an 11.8 percent decline in the overall global demand for rare earths from 2010 to 2013,[16] earlier forecasted growth in demand through 2016 has been revised downward.[17] The Department projects almost no growth in U.S. defense demand for rare earths between 2015 and 2018.[18]

- The demand for rare earths has also changed in a number of significant ways that has provided additional benefits to buyers and consumers of these materials. Specifically, important segments of the demand for rare earths have essentially been eliminated or greatly diminished, easing the overall demand for rare earths. Pressures on the demand for rare earths have declined because of a number of factors, including private sector market responses to develop substitutes for rare earths as well as other efforts to reduce the demand for rare earths. Examples include designing products that are less dependent on rare earths (e.g., reduced use of heavy rare earth dopants in magnets), replacing the use of scarce heavy

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[15] *The Global Rare Earths Industry: Poised for Growth*, by Dudley J. Kingsnorth, November 2012.

[16] Curtin-IMCOA, *Rare Earths Quarterly Bulletin #5*, by Dudley J. Kingsnorth, June 2013.

[17] *The Global Rare Earths Industry: Poised for Growth*, by Dudley J. Kingsnorth, November 2012.

[18] 2013 Report on Stockpile Requirements

rare earths with more widely available light rare earths, re-using rare earth polishing materials, and, in certain cases, doing away with the use of rare earths in products all together (e.g., increased use of LED lighting, Li-ion batteries, and ferrite magnets that use much less or no rare earth elements).

- Different industry sectors that make significant use of rare earths in manufacturing have found ways to either increase internal production efficiencies so as to ultimately reduce rare earth containing scrap (e.g., generated from the production of new magnets) or reintroduce into their production processes rare earths recovered from recycling end-of-life products (e.g., rare earth recovered from phosphors used in discarded light bulbs).
- Additionally, there are a variety of U.S. as well as international industry, academic, and government-sponsored rare earths materials and processing research activities underway. Regarding the latter, U.S. government agencies, including DoD, are funding rare earths research projects in rare earths reclamation such as recycling rare earths from end-of-life consumer products (magnets) and industrial waste (fly ash) as well as processing rare earth containing tailings from earlier mining operations.

Rare Earth Recycling and Reclamation

Federal Programs

Because of favorable rare earth market conditions for consumers of rare earths, the lack of sufficient U.S. defense requirements (as reported in DoD's recent 2013 Report on Stockpile Requirements and as evidenced by a lack of rare earth supply interruptions that have significantly disrupted major U.S. defense programs and military capabilities), and the relative lack of economic viability for rare earth reclamation and recycling in the United States, DoD does not have any operational-level (i.e., commercial-scale) rare earth reclamation programs (current or planned).

Nevertheless, DoD is actively assessing current and future rare earth supplies and Department-wide demands (currently through 2020 for the next Report on Stockpile Requirements to the Congress), and DoD has made investment resources available for rare earth materials and processing research and development (R&D). Research has focused on supporting advancements in improved rare earths materials processing and recycling. Examples of DoD research funding have included industry research funding for rare earth metal refining by the Army and early-stage small business R&D funding by the Navy for reclaiming rare earths from waste material streams. Other DoD R&D programs have been made available to support rare earth materials process development: Defense Logistics Agency (DLA) Strategic Materials' research Broad Agency Announcement, the Title III program of the Defense Production Act, the Defense Manufacturing Technology program, and DoD's Rapid Innovation Program.

DoD will continue to support these and related rare earth materials and processing R&D activities—including those specifically related to rare earths reclamation technologies—as defense research opportunities and related U.S. military requirements dictate.

Beyond the DoD R&D activities noted above, other federal agencies, primarily the Department of Energy (DoE) at its Critical Materials Institute and the National Science Foundation, are

supporting research programs into rare earth recycling and reclamation (see https://cmi.amerslab.gov/research/improving-reuse-recycling). The Critical Materials Institute was established by DoE to help the United States avoid the impact of supply availability concerns for certain materials, including rare earths, by developing technologies that will make better use of the materials to which we have access as well as eliminate the need for materials that are subject to supply disruptions. It is sponsoring several research projects related to rare earth reclamation, including: the recovery of rare earth metal oxides from lamp phosphor dusts; the electro-chemical recycling of rare earth metals from electronic wastes; and the study of the logistics and economics of rare earth remanufacturing and recovery. The National Science Foundation is sponsoring several projects at colleges and universities related to rare earth reclamation, including the study of: biological and chemical technologies related to rare earths and critical materials; advanced manufacturing and nanotechnology for rare earths and critical materials; and magnet separation technologies for recycling. The Environmental Protection Agency also is sponsoring research concerning the cost-effective recycling of rare earth magnetic alloys and permanent magnets from industrial scrap and discarded electronic products.

These government programs are developmental because, with the exception of the two examples of the reclamation of material from fluorescent light phosphors and NiMH batteries outside of the United States, the current state of the technology for rare earth recovery does not allow material to be reclaimed economically (in the North American market) from products at the ends of their lives. While the technology exists to recover rare earths from several other sources (e.g., NdFeB magnets in computers and electronic components, thermal barrier coatings in turbine engines, and automotive catalytic converters), such recovery does not appear economical under current market conditions for these application areas.

The situation is somewhat different in Europe, where more stringent environmental laws require the collection and processing of certain rare earth-bearing waste products and thereby make the recovery of rare earths more attractive there. Two such product types from which rare earths are recovered on a commercial scale today are fluorescent lights in France and NiMH batteries in Belgium.[19] In Japan, rare earths are being recovered, on a limited scale and potentially developmental basis, from magnets from computers, consumer electronics, and household appliances, and from NiMH batteries from hybrid cars.

While DoD is not choosing to take commercial scale programmatic actions on the reclamation prong of its rare earth risk mitigation strategy right now (i.e., beyond limited research activities), DoD is prepared to take advantage of existing private sector capabilities as well as any future capabilities that may result from industry and other R&D programs that could help meet U.S. defense demands for rare earths as circumstances change and DoD's requirements dictate (e.g., anticipation of significant interruptions of future supply and that would result in major disruptions to U.S. defense programs and military capabilities).

As noted above, the DoD and other U.S. government programs concerning rare earth recycling and reclamation are largely in the research and development stage. Their goal is to develop

[19] The European firm that reclaims rare earth oxides from NiMH batteries also collects batteries in the United States for recovery of the material in Europe. The European firm that reclaims rare earths from fluorescent lamps also receives mixtures of rare earth oxides extracted from lamp phosphors in stages by two U.S. firms that it then separates into individual rare earth oxides.

cost-effective recycling and reclamation capabilities. Researchers estimate that they will lead to commercialization mostly in the mid to longer-term, roughly 5 to 7 years from now. Therefore, this report cannot state the costs of the rare earth materials that they will produce compared to the cost of mined or newly produced materials.

Reclamation Resources Investigated

DoD has investigated potential alternative sources of supply of rare earths in several respects. In 2012, the Secretary of Defense submitted a report to Congress on the feasibility and desirability of recycling, recovering, and reprocessing rare earth elements.[20] The study that produced the report investigated the following major DoD applications for rare earths for their potential for recycling and recovery:

- Neodymium-iron-boron (NdFeB) magnets
- Samarium-cobalt (SmCo) magnets
- Phosphors used in displays
- Phosphors used in lighting
- Ceramics and glass
- Fiber optics
- Nickel-metal hydride (NiMH) battery alloys
- Metal alloys
- Lasers

Those applications were evaluated based on the availability of the rare earth materials in various systems and forms; the state of the materials processing technologies and collection, storage, and transportation infrastructures; and the economics of the materials recovery processes. The following five application areas were identified as offering the greatest theoretical potential for recycling and recovery: phosphors for lighting and visual displays, NdFeB magnets in computers and electronic components, NiMH battery alloys, high-temperature ceramics and ceramic coatings from turbine engines, and automotive catalytic converters.

In addition to that effort, DoD (the Office of Naval Research) is currently sponsoring research into the potential reclaiming rare earth elements from coal fly ash. It (DLA Strategic Materials and the Navy) is also exploring the feasibility of recycling rare earth laser crystals at the end of the life cycle.

In evaluating DoD rare earth application areas for their potential for recycling and recovery, the 2012 DoD study estimated the quantity and form of rare earth elements that could theoretically

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[20] Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, *Report on Feasibility and Desirability of Recycling, Recovery, and Reprocessing Rare Earth Elements* (September 2012). The report was prepared pursuant to a request in House Report 112-329, accompanying the Fiscal Year 2012 National Defense Authorization Act, that the Secretary "prepare a report on the feasibility and desirability of recycling, recovering, and reprocessing rare earth elements, including fluorescent lighting in Department of Defense facilities, batteries, and neodymium iron boron magnets used in weapon systems and commercial off-the shelf items such as computer hard drives."

be recovered by recycling products after the ends of their lives. The estimates were theoretical in that in some cases the technology of recycling and recovery remains challenging, and for all cases (with the exceptions of lamp phosphors and NiMH batteries noted above), the market has not yet found rare earth recycling and recovery to be economical, in that there are no commercial scale rare earth recycling and recovery operations in North America today. The estimates of potential material availability from DoD applications were as follows.

Table 1: 2012 Estimate of Rare Earths Theoretically Recoverable from DoD Applications

Product Type	Rare Earth	Potential Annual Amount (MT)
Fluorescent Lamps	Yttrium oxide	58
	Europium oxide	4
	Erbium oxide	3
Nickel Metal Hydride Batteries	Lanthanum	3.5 to 5
	Neodymium	3.5 to 5
Neodymium Magnets from Computers and Other Electronic Components	Neodymium	3.5
	Praseodymium	1
	Dysprosium	0.25
	Gadolinium	0.1
	Terbium	0.01
Thermal Barrier Coatings	Yttrium oxide	5
Automotive Catalytic Converters	Cerium oxide	20

Mine Tailings

In addition to rare earth-containing wastes that could potentially be reclaimed (pending technological and/or market developments), there are also mine tailings in the United States that contain rare earths that could potentially serve as a source of additional supply.[21] At the Mountain Pass mine in California, the tailings basin contains up to 5 percent rare earth oxide (in monazite) and the tailings mounds contain approximately 2 to 5 percent rare earth oxide. The total amount of rare earths contained in the Mountain Pass tailings is significant—they could be characterized as the second largest deposit of rare earths in North America (next to the deposits in the ground at Mountain Pass).[22] Tailings associated with the Pea Ridge, Missouri, iron ore

[21] Keith R. Long et al., *The Principal Rare Earth Elements Deposits of the United States—A Summary of Domestic Deposits and a Global Perspective*, U.S. Geological Survey (2010); see also U.S. Environmental Protection Agency, Office of Research and Development, *Rare Earth Elements: A Review of Production, Processing, Recycling, and Associated Environmental Issues* (December 2012), Appendix B (listing rare earth containing mineral deposits in the United States, including currently and formerly active mine sites).

[22] Keith R. Long et al., The Principal Rare Earth Elements Deposits of the United States—A Summary of Domestic Deposits and a Global Perspective, U.S. Geological Survey (2010).

body and mine and the former iron mines near Mineville, New York, also contain significant quantities of rare earths. There are also tailings associated with some other mineral developments (e.g., phosphate minerals) that contain rare earths. The U.S. Geological Survey is continuing to evaluate potential domestic sources of rare earths. DoE is sponsoring some research into the development of technologies that could make the recovery of materials from mine tailings more effective. Future exploitation of tailings resources will depend on technological, regulatory, and/or market developments.

The Use of the Defense Priorities and Allocations System for Rare Earth Materials

In addition to questions concerning rare earth recycling and reclamation, the House Report also requests a description of the materials that the Department plans to obtain via the Defense Priorities and Allocations System (DPAS). The DPAS is typically applied at a program-level basis rather than to individual raw materials. Once a program is given a DPAS rating, the rating is extended to all U.S. contracts and subcontracts within the program, including material suppliers if applicable. The Unite States has no ability to rate a contract from a foreign supplier unless a Security of Supply Arrangement has been established with the foreign country and the supplier has agreed to comply with the Arrangement. Most DoD programs have a DPAS rating[23]. Exceptions are some non-critical items like commonly available commercial goods and goods that do not directly support logistics, tactical, or operational program requirements.[24] It is estimated that 300,000 contracts and purchase orders annually include priority ratings. The Department does not track which of those orders maybe related specifically to rare earth materials.

Potential Conflict Risk and Mobilization and Other Risk Mitigation Measures

DoD assesses rare earths supply risks in the context of both current peacetime conditions and mobilization and potential large scale conflict scenarios. As noted above, DoD has not identified major risks of severe disruptions under current peacetime conditions of the rare earths supply for the U.S. defense industrial base generally or for specific DoD defense acquisition programs. DoD's Department-wide assessment of rare earths supply risks within the context of a major national emergency (including large scale conflicts) is conducted by DoD's National Defense Stockpile (NDS) program and the NDS biennial Stockpile Requirements Report process. The NDS program and its requirements development process is DoD's primary Department-wide means for identifying and mitigating future risks to the anticipated supply of strategic and critical materials—primarily at the raw materials level of ores and concentrates and including rare earth elements.[25] DoD's requirements are determined for all U.S. defense demands and essential civilian demands within the context of a congressionally-mandated national emergency scenario.

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[23] 15 CFR Part 700 (Defense Priorities and Allocations System); DoD 4400.1M, *Department of Defense Priorities and Allocations Manual*, Feb 21, 2002.

[24] While most DoD orders receive DPAS ratings (DO and DX), a contractor will ordinarily not move a DPAS rated order (DO or DX) ahead of an unrated order unless it is necessary to meet the delivery schedule for the rated order. Note also that bilateral security-of-supply arrangements with foreign governments allow DoD to request priority delivery for contracts and orders from companies in signatory countries.

[25] The NDS process monitors and assesses risk related to over 100 individual materials.

With the exception of a small quantity of one specialty rare earth compound, DoD's most recent Report on Stockpile Requirements to the Congress estimated no shortfall of rare earths materials for U.S. defense needs during a postulated national emergency scenario in the 2015 to 2018 time period.[26]

That said, DoD recognizes potentially unique risks to the supply of selective rare earth materials, such as certain heavy rare earth elements; related separation and purification production capabilities; and the capabilities and capacities to produce downstream value added materials and associated products including various rare earth compounds, metals and alloys.[27] For these purposes, DoD has been undertaking extensive "downstream" supply chain assessments of various rare earth containing materials (e.g., magnets, ceramics, structural alloys, specialty metals and chemicals) that may be of particular importance to U.S. defense acquisition programs and the military capabilities these programs support.

For these and other reasons, DoD is in the process of establishing an initial stockpile of select rare earth containing materials (including refined metals and specialty chemicals). DoD is additionally pursuing an expansion of the legal authorities for the NDS program to further utilize recycled materials for stockpiling and related purposes, which will help enable DoD to take greater advantage of future market developments in rare earth reclamation.

As a final matter regarding the mitigation of risk associated with rare earths, it should be emphasized that in addition to the discrete actions discussed above, DoD's strategy includes broadly the constant, active monitoring of the global situation concerning rare earths, the assessment of its implications for the Department's supply of rare earths, and the consideration of actions to be taken to mitigate risks as the situation warrants. DoD has been paying increasing attention to rare earths as market developments have suggested the existence of possible threats to its supply:

- In 2011, OUSD(AT&L) presented its 2011 *Report To The Congress On National Defense Stockpile Requirements* in which it evaluated the supply of and demand for seven rare earth elements under its statutory NDS planning scenario (and others) and recommended them for inclusion in the Stockpile (to mitigate shortfalls of material needed for essential civilian demands (no defense shortfalls were identified)). It also discussed alternatives to stockpiling for mitigating material shortfalls.
- In January 2012, OUSD(AT&L) presented its aforementioned report, *Rare Earth Materials in Defense Applications*, in which it assessed the supply of and the defense applications for all 17 rare earth elements and stated its rare earth risk mitigation strategy. That report noted the forthcoming construction of the Hitachi neodymium-iron-boron magnet plant in North Carolina (which is now operating) as a market response mitigating a vulnerability in an important U.S. rare earth supply chain. This document estimated that only one rare earth at the raw material level, yttrium, would be in shortfall for U.S. defense purposes.

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[26] As noted elsewhere in this report, the 2013 NDS Requirements Report identified rare earth shortfalls for essential civilian demands.

[27] *Annual Industrial Base Capabilities Report to Congress*, submitted by the Under Secretary of Defense for Acquisition, Technology and Logistics, Office of the Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy, October 2013.

- In September 2012, OUSD(AT&L) presented its aforementioned *Report on Feasibility and Desirability of Recycling, Recovery, and Reprocessing Rare Earth Elements*, in which it evaluated the potential for rare earth recycling to mitigate supply risks.
- In December 2012, the Office of the Secretary of Defense presented its *Report to Congress on Assessment of Feasibility and Advisability of Establishment of Rare Earth Material Inventory*, in which it assessed the feasibility and advisability of establishing an inventory of rare earths to assure their long-term availability (recommending ultra-pure yttrium oxide for addition to the Stockpile) and stated the further actions the Department intended to take to assure its rare earth supply. That report did not identify further shortfalls for U.S. defense requirements at the raw material level. However, uncertainties regarding the supplies of certain heavy rare earth raw materials, higher purity oxides, related compounds, and semi-finished products made it advisable to maintain a high level of surveillance, assess and establish mitigation solutions of semi-processed rare earth containing materials, and maintain larger inventories of spares for critical systems.
- In January 2013, OUSD(AT&L) presented its *Strategic and Critical Materials 2013 Report on Stockpile Requirements*, in which it assessed risks arising from the supply of and demand for all 17 rare earth elements under the NDS planning scenario and recommended four for stockpiling to cover essential civilian shortfalls. It also discussed in more depth alternatives to stockpiling for mitigating material shortfall risk. With the exception of a relatively small quantity of a specialized rare earth compound, this report did not estimate any rare earth material shortfalls for U.S. defense specific needs.
- In October 2013, OUSD(AT&L) presented its most recent *Annual Industrial Capabilities Report to Congress*, in which it discussed recent developments in the rare earths markets in the United States and overseas, including efforts made by the market and by the Department to reduce rare earths supply risks.
- DLA Strategic Materials is now assessing, for the FY 2015 *Report on Stockpile Requirements*, the risks arising from the supply of and demand for the rare earths under the NDS planning scenario. It is extending its material assessments to include risks arising from vulnerabilities in selected global supply chains (downstream of raw material production) for defense and essential civilian demands. It is also continuing to develop its approach to evaluating alternatives to stockpiling for mitigating material shortfall risk.

Thus, DoD has made considerable efforts since 2011 to assess risks to the Nation's supply of rare earths and will continue to do so into the future as part of pursuing its risk mitigation strategy.

Conclusion

In response to the House Report 113-102 request for this report on DoD's risk mitigation strategy for rare earth elements and the House Report's focus on the reclamation of waste, the Department concludes as follows:

- It is the Department's overall strategy to ensure the supply of rare earth materials by: (1) actively monitoring material demand and supply; (2) assessing risks; and (3) considering the benefits and costs of mitigation options.

- In addition to constant, active monitoring of the global situation concerning rare earths, the Department's specific three-part strategy for mitigating the potential risk to the supply of rare earths includes: (1) leveraging diversification of supply, (2) taking advantage of substitutes, and (3) using materials available from the reclamation of waste. DoD is implementing this overall strategy for rare earth materials, and remains ready to take further risk mitigation actions using particular options as appropriate.

- The Department observes that the peacetime supply of rare earths for U.S. defense acquisition programs is not presently being disrupted and it expects no shortfalls of rare earths for U.S. defense demands through the 2015 to 2018 timeframe—even in the context of a major national emergency when some supply interruptions would be expected to occur.

- From the perspective of users of rare earths, market supply and demand conditions overall have significantly improved in the United States and internationally since 2010 and 2011. There has been a significant decrease in the demand and prices for rare earths as well as an increase in the availability of supply including material surpluses and diversification in production.

- DoD recognizes potential risks involving certain aspects of rare earth supply, such as some heavy rare earths, downstream separation and purification capabilities, and the capabilities and capacities to produce further value added materials and associated products. To address these risks, DoD has been undertaking extensive "downstream" supply chain assessments of rare earth containing materials that may be of particular importance to U.S. defense programs, and where appropriate, initiated risk mitigation strategies (e.g., received recent authorization by the Congress to stockpile a specialty rare earth oxide for lasers used in U.S. military systems and investigating re-use of related materials from old military systems).

- With respect to rare earth reclamation, DoD has evaluated the applications for which it uses rare earths and the potential for the recovery of rare earths from those applications. DoD observes that reclamation technologies largely remain immature and/or otherwise cost prohibitive, and thus, there is limited to no commercial-scale recycling of post-consumer waste or mine tailings in North America.

- For the foregoing reasons, DoD has not yet seen a compelling need to take programmatic action with respect to commercial scale rare earth recycling and reclamation, and it does not currently have any operational-level recycling and reclamation defense programs. DoD is supporting, and will continue to support, rare earth materials research and related assessments, including those concerning recycling and reclamation. Where appropriate, it will leverage related research activities supported by other U.S. agencies, industry, and academia.

- Moving forward, and as a regular part of its larger strategy in the area of strategic and critical materials risk mitigation, DoD will continue to actively monitor rare earth markets, assess potential risks to its supply, evaluate U.S. defense needs, consider risk

mitigation options, and related DoD program requirements. Those assessment efforts have led the Department to undertake further risk mitigation measures.

- DoD remains prepared to take additional actions on its rare earth risk mitigation strategy as circumstances warrant while the U.S. defense industrial base is prepared to take advantage of future rare earth market opportunities as they may develop (e.g., increased supply opportunities that may later develop from private sector progress in rare earths reclamation).

Appendix 1: Fiscal Year 2014 National Defense Authorization Act, House Report 113-102

National Defense Authorization Act for Fiscal Year 2014 Report of the Committee on Armed Services House of Representatives

TO ACCOMPANY

H.R. 1960

June 7, 2013

Report on Diversification of Supply Activities Related to Rare Earth Elements

The committee is aware that in response to the report required by section 843 of the Ike Skelton National Defense Authorization Act for Fiscal Year 2011 (Public Law 111–383) and based on forecasting demand for fiscal year 2013 only, the Under Secretary of Defense for Acquisition, Technology, and Logistics concluded that domestic production of rare earth elements could satisfy the level of consumption required to meet defense procurement needs by fiscal year 2013, with the exception of yttrium. However, the committee observes that the Future Years Defense Program indicates that consumption of rare earth elements is expected to increase after 2013. Specifically, the report on the feasibility and desirability of recycling, recovery, and reprocessing of rare earth elements required by the conference report (H. Rept. 112–329) to accompany the National Defense Authorization Act for Fiscal Year 2012, states that each SSN–774 Virginia-class submarine would require approximately 9,200 pounds of rare earth materials, each DDG–51 Aegis destroyer would require approximately 5,200 pounds of these materials, and each F–35 Lightning II aircraft would require approximately 920 pounds of these materials.

The committee is aware that the Department of Defense intends to pursue a three-pronged strategy to secure supplies of rare earth elements, which consists of diversification of supply, pursuit of substitutes, and a focus on reclamation of waste, as part of a larger U.S. Government recycling effort. The committee believes that diversification of supply activities related to rare earth elements is necessary in order to meet the growing demand for these materials, but the committee is concerned that some of these processes may prove to be technically difficult or so expensive that they are deemed cost-prohibitive.

Therefore, the committee directs the Under Secretary of Defense for Acquisition, Technology, and Logistics to submit a report to the congressional defense committees by February 1, 2014, on the Department's risk mitigation strategy for rare earth elements, which should include, at a minimum, the following elements:

(1) A list and description of the programs initiated or planned to reclaim rare earth elements by the Department, along with a description of the materials reclaimed or expected to be reclaimed from such programs;

(2) An assessment of the cost of materials produced by these reclamation efforts compared to the cost of newly-mined materials;

(3) An assessment of availability of reliable suppliers in the National Defense Industrial Base for the reclamation and reprocessing of rare earth elements;

(4) A list of alternative sources of supply, such as mine tailings, recycled components, and consumer waste, that the Department has investigated or plans to investigate;

(5) A physical description of alternative sources of supply with corresponding geologic characteristics, such as grade, resource size, and the amenability of that feedstock to metallurgical processing;

(6) A description of the materials that the Department plans to obtain via the Defense Priorities and Allocations System;

(7) Other diversification of supply activities deemed relevant by the Under Secretary.