U.S. STRATEGIC MATERIAL SUPPLY CHAIN ASSESSMENT: SELECT RARE EARTH ELEMENTS

DYSPROSIUM, ERBIUM, NEODYMIUM, TERBIUM, AND YTTERBIUM

2016

PREPARED BY
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Table of Contents

I. Introduction and Select Findings 3

II. Industry Profile 11

III. Sales and Financial Performance 20

IV. Products and Inputs 29

V. Organizational Challenges, Competitiveness, and Capital Expenditures 46

VI. Innovation: Substitution, Recycling, and R&D 61

VII. Support for U.S. Government Agencies 74

VIII: Trade 82

IX. Employment 97

X. Findings 106

Appendix 1. Business Line Definitions 114

Appendix 2. Survey Instrument 116

Appendix 3. Office of Technology Evaluation Publications List 150

I. Introduction and Select Findings

Rare Earth Elements (REEs), also called rare earth metals and rare earth oxides, are a group of seventeen chemical elements moderately abundant in the earth's crust, with unique properties essential to high-technology products. REEs are used in metallurgy, polishing, and the creation of catalysts and magnets, with a range of applications including automobile and petroleum refining, phosphors for flat panel displays in mobile phones and laptops, permanent magnetics, and rechargeable batteries.[1] REEs are also vital in defense applications such as fighter jet engines, missile guidance systems, lasers, and satellite communications systems.

The United States was once self-reliant in its domestic mining industry for REEs, but has become nearly fully reliant on REE imports in the past 20 years. This import reliance has come about due to increasing foreign competition, primarily from China, which has lower mining and processing costs and significantly larger REE reserves, as well as from increased domestic and foreign usage of REEs. This report focuses on the U.S. manufacturers and distributors that require REEs for their products. While domestic production of REEs shrank in the last half century, the growth of the global technology industry has spurred a continually increasing demand for REEs in commercial and defense markets.

The Chinese near-monopoly on REEs has raised the issue of supply vulnerability in recent years. Temporary Chinese export restrictions of certain REEs have caused extreme price volatility and global end-user outcry. China has since dropped these restrictions, but their unilateral action has

[1] Find more information on rare earth elements at https://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/

raised concerns with numerous U.S. Government institutions including Congress and the U.S. Department of Defense.

In 2014, the U.S. Department of Defense, Defense Logistics Agency (DLA) partnered with the U.S. Department of Commerce, Bureau of Industry and Security (BIS) to conduct an industrial base assessment measuring the health and competitiveness of the domestic REE supply chain network, focusing on manufacturers and distributors of products containing REE components used in defense and aerospace applications. The following report focuses on five specific REEs: Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium, collectively referred to as "DENTY".

DLA also requested similar assessments focusing on the carbon fiber composites, magnesium, and titanium industries. These materials are covered in separate BIS reports.[2]

BIS and DLA set the following objectives for the industrial base survey and assessment:

- Capture the various levels of the REE supply chain network.
- Identify interdependencies between respondents, their suppliers and customers, and the U.S. Government agencies they support, with particular focus on supply chain availability issues and challenges.
- Benchmark trends in business practices, competitiveness issues, financial performance, research and development (R&D) and capital investment, workforce, and other topic areas across the supply chain network.

[2] View these and other industrial base reports on the BIS webpage: www.bis.doc.gov/dib.

- Share data with U.S. Government (USG) stakeholders, as appropriate, to better inform strategic planning, policy implementation, targeted outreach, and collaborative problem solving.

BIS performed this data collection and assessment under authority delegated to the U.S. Department of Commerce under Section 705 of the Defense Production Act of 1950, as amended, and Executive Order 13603. These authorities enable BIS to conduct surveys, study industries and technologies supporting the national defense, and monitor economic and trade issues affecting the U.S. industrial base.

Other industrial base assessments recently completed by BIS include: the U.S. Underwater Acoustics Transducer Industry, the U.S. Space Industry "Deep Dive," the Cartridge and Propellant Actuated Device Industry, and the Consumers of Electro-Optical Satellite Imagery.[3]

BIS worked with DLA and select DENTY suppliers and product manufacturers to gain a better understanding of operational and business practices specific to the REE industry. These interactions aided in designing a survey instrument that covered issues faced by both industry and government stakeholders.

The content of the survey instrument addresses several categories of respondent information, including sections dedicated to:

- Organizational information
- Products (DENTY-related)
- Suppliers, inventories, inputs, and sourcing

[3] See www.bis.doc.gov/dib.

- U.S. Government defense and non-defense participation
- Operations and Challenges
- Imports and Exports of REE-Related Material
- Sales
- Customers
- Financials
- Workforce
- Research and Development
- Capital Expenditures

BIS distributed the REE survey in late spring 2014 to respondents identified by DLA (our partner agency), previous BIS survey efforts, and independent research. A total of 160 organizations responded to the survey. The response data was reviewed, tabulated, analyzed, and presented to DLA to facilitate their analysis and strategic planning. Additionally, aggregated results, as contained in this report, were made publicly available and presented to strategic materials stakeholders across the U.S. Government, industry, and academia.

Select Findings

- Most respondents were focused on Manufacturing, Distribution, End-Use/Application, and R&D; these four business lines accounted for 82 percent of the primary business lines selected by respondents.
- The 160 respondents reported operating 396 facilities: 288 in 38 states and 108 in 33 non-U.S locations between 2010 and 2013. Respondents had the greatest number of facilities

in California, New Jersey, and New York. For the 108 facilities outside of the United States, most were in China, Germany, the United Kingdom, France, and Canada.

- Aggregated sales of all respondents were $76.4 billion in 2013. REE-related products accounted for only 8 percent of this amount - $6.1 billion – up from 5.8 percent in 2010. REE sales growth in the commercial area far outpaced that in the governmental area.
- For the 2010-2013 period, three respondents were calculated to be at high/severe financial risk, with another 36 at moderate/elevated financial risk.
- The 160 respondents identified a total of 601 products or product types. Over two-thirds of the listed products were related to the DENTY elements; the majority of these products were magnets and magnet powder products.
- Nearly half of the products or services used Neodymium, which was used at over twice the rate of each of the other elements of focus (Dysprosium, Ytterbium, Erbium, and Terbium). Most products/services involved the use of more than one REE.
- Respondents listed 24 inputs with sole source suppliers and 128 inputs with single source suppliers.[4] Chemicals and Magnets had the greatest number of sole source and single source inputs. On a percentage basis, over three-quarters of alloy and ceramic inputs were sole or single source.
- REEs originating in China represented approximately two-thirds of inputs, with those from the United States accounting for another 22 percent. All remaining countries

[4] Single Source – An organization that is designated as the only accepted source for the supply of parts, components, materials, or services, even though other sources with equivalent technical know-how and production capability may exist.
Sole Source – An organization that is the only source for the supply of parts, components, materials, or services. No alternative U.S. or non-U.S. based suppliers exists other than the current supplier.

accounted for just under 10 percent of known origin REEs, with no single country accounting for more than eight inputs.

- Supply chain disruptions were only a minor issue for respondents in 2012 and 2013. Seven respondents reported 16 total supply chain disruptions. Eleven of these disruptions were for suppliers located in China, where China was the original source of the REEs as well. The reasons given for disruptions were varied, including legal holdups, quality issues, and significant price increases.
- Eighty-one of 160 respondents ranked 'Foreign Competition' as an organizational challenge, with 30 noting it as their number one challenge. This was more than twice the number of the next most frequent primary challenge, 'Material Price Volatility'.
- 'Aging Equipment, Facilities, or Infrastructure' was not a highly cited challenge overall, but was the most frequently identified challenge expected to rise in the future.
- Respondents did not expect any major changes in the availability of any REEs in the near future. For every REE, the vast majority of respondents expected no change in its availability.
- Recycled products and inputs were twice as common as substituted products and inputs. Twenty-three percent of respondents recycled REEs or REE-related products, whereas six percent of respondents substituted REEs with other REEs or non-REEs.
- Product Performance was the most frequently cited constraint in using recycled REEs or substituting for REEs.
- Sixty-one respondents reported having REE-related R&D expenditures, totaling $254 million in 2013 – four percent of total R&D expenditures for all respondents.

- One hundred two of the respondents provided support to at least one USG agency, with USG sales accounting for nearly one-third of all sales in 2013. The Armed Services, NASA, and the Department of Energy were the most frequently supported agencies.
- Forty-seven respondents were seemingly dependent on the USG, based on their indication as such and/or their percent of sales to the USG.
- Sixty-six respondents indicated they imported REE-related ore, mixed compound, inorganic purified compound, organic purified compound, mixed metal, and/or purified metal between 2010 and 2013. Forty-six respondents imported from a single country, with China accounting for 28 (61 percent) of these single country importers.
- Respondents reported a total of $1.1 billion worth of imports of REE-related ore, compounds, and metals from 2010 to 2013. The top three importers accounted for nearly $688 million of these imports (63 percent), and the top five accounted for 80 percent of imports.
- Thirty-six respondents (23 percent) reported exports of REE-related ore, compound, or metal to 56 countries between 2010 and 2013. Another 36 respondents listed non-U.S. customers of their products or services.
- In 2013, the 160 respondents employed 203,896 total full-time-equivalent employlees (FTEs), 5.6 percent of whom performed REE-related duties.
- Smaller companies tended to have a larger percentage of their workforce devoted to REE-related items. Small and medium sized businesses had 26 and 28 percent of their employees, respectively, working on REE-related items, compared to 17 percent for large businesses and three percent for very large businesses.

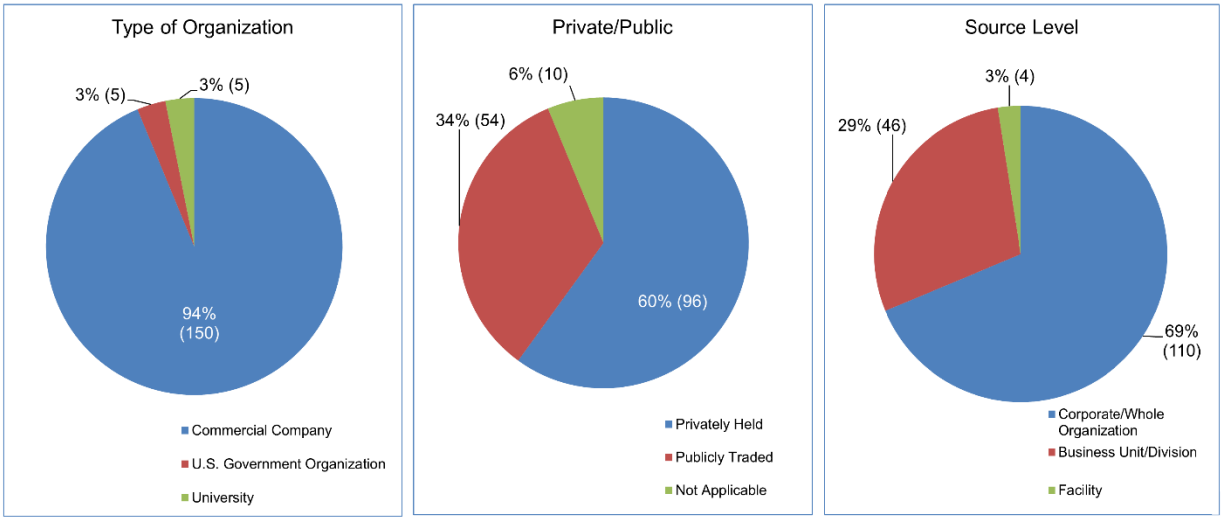
II. INDUSTRY PROFILE

BIS received surveys from 160 respondents of all sizes, from many locations within the United States, who work with Rare Earth Elements (REEs) in some capacity along the value chain. In order to capture some initial information about the respondents and create organization profiles for further analysis, BIS asked a series of questions about organization size and type. The profile questions also asked that respondents detail their lines of business, REE applications, and the market segments in which they participated. Finally, BIS asked respondents to list their organization's facility locations and any anticipated changes for those facilities.

All 160 of the total respondents worked directly with REEs. One hundred and forty respondents (88 percent) worked directly with the focus elements: Dysprosium, Erbium, Neodymium, Terbium, or Ytterbium (DENTY).

Respondent organizations fell into one of three types of organization: Commercial Company, U.S. Government Organization, or University. One hundred and fifty respondents (94 percent) were Commercial Companies; five respondents (three percent) were Universities; and five respondents (three percent) were U.S. Government Organizations. Commercial companies were then further divided into publicly traded or privately held companies. Ninety-six of the 150 commercial companies (not including the 'Not Applicable' category) (60 percent) were privately held organizations. Forty-six organizations (29 percent) responded at the business-unit or division-level, providing more REE focus to their responses (see Figure II-1).

Figure II-1: Respondent Profile



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Sixty-six respondents (41 percent) self-identified as a small business, while 115 respondents (72 percent) reported having fewer than 500 employees in 2013. For the purposes of this assessment, respondents were classified as small, medium, large, or very large companies based on their average net sales from 2010 to 2013 (rather than their employee size).

Using average net sales to categorize the respondents by size, small businesses were defined as respondents with average annual sales under $25 million. Using this method, 74 respondents (46 percent) were categorized as small. These small businesses employed roughly one percent of the nearly 230,000 reported full-time equivalent (FTE) employees. Very large organizations accounted for six percent of the survey responses, but employed 67 percent of the total reported employees on average between 2010 and 2013 (see Figure II-2).

Figure II-2: Respondent Size Categorizations

by Average Annual Net Sales, 2010-2013
(Includes Commercial Companies, Universities, Non-Profit Organizations, and USG Organizations)

Size	Average Annual Net Sales	Number of Respondents	Average Number of Employees	Average Number of REEs Used
No Sales	None Listed	21	1,274	9.7
Small	Under $25 Million	74	48	5.2
Medium	$25 Million - $100 Million	28	157	6.6
Large	$100 Million - $1 Billion	27	1,157	5.9
Very Large	$1 Billion or Greater	10	13,796	7.6

Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

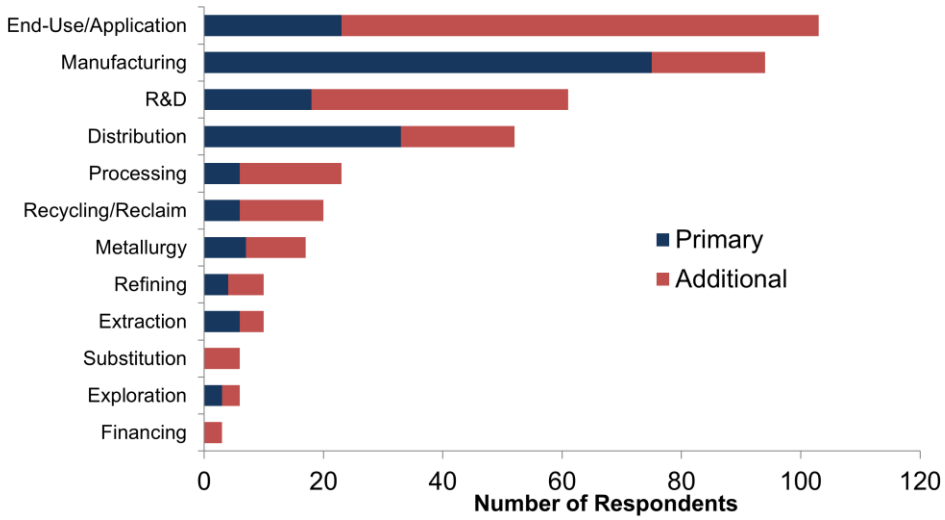
Respondents provided their role in the REE supply chain by reporting their primary and additional lines of business from a list BIS provided (see Appendix 1). Results indicated that U.S. companies working with REEs are generally involved in the later processing stages, rather than earlier procurement stages (see Figure II-3). REE mining activities—such as 'Financing', 'Exploration', and 'Extraction'—were selected as primary business lines for only nine respondents (6 percent). Seventeen respondents (11 percent) reported one of the following as their primary line of business: 'Processing', 'Metallurgy', or 'Refining'.

Respondents identified four business lines significantly more frequently than others: 'End-Use/Application', 'Manufacturing', 'Research & Development (R&D)', and 'Distribution'. 'Manufacturing', with 75 respondents (47 percent), was the most commonly selected primary business line, followed by 'Distribution'. 'End-Use/Application' was only the fourth most commonly reported primary business line, but was the most commonly reported category overall

when including additional business lines with 103 respondents (64 percent). 'R&D' was reported as a business line by 61 respondents (38 percent), although 111 respondents (69 percent) reported having R&D expenditures.

Figure II-3: Respondent Business Lines

12 Business Lines: Primary and Additional

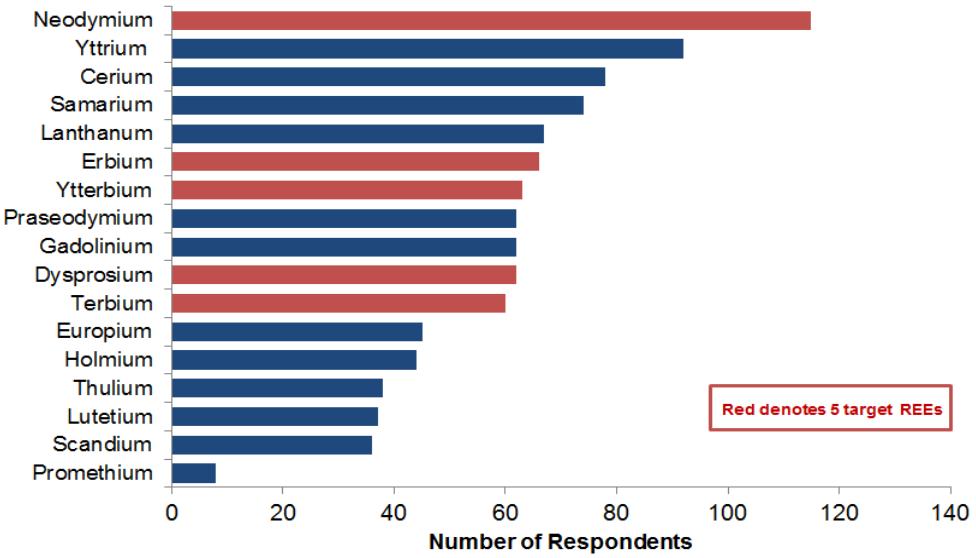


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Within these business lines, respondents utilized a variety of REEs (see Figure II-4). The most commonly used element, 'Neodymium', with 115 respondents reporting usage, was a focus element of this survey. The second and third most widely used elements were 'Yttrium' and 'Cerium', with 92 and 78 respondents, respectively. Usage of the other assessment target elements ('Dysprosium', 'Erbium', 'Terbium', and 'Ytterbium') was reported by between 60 and 66 respondents each.

Figure II-4: REE Participation

Respondents that "work with" 17 different REEs



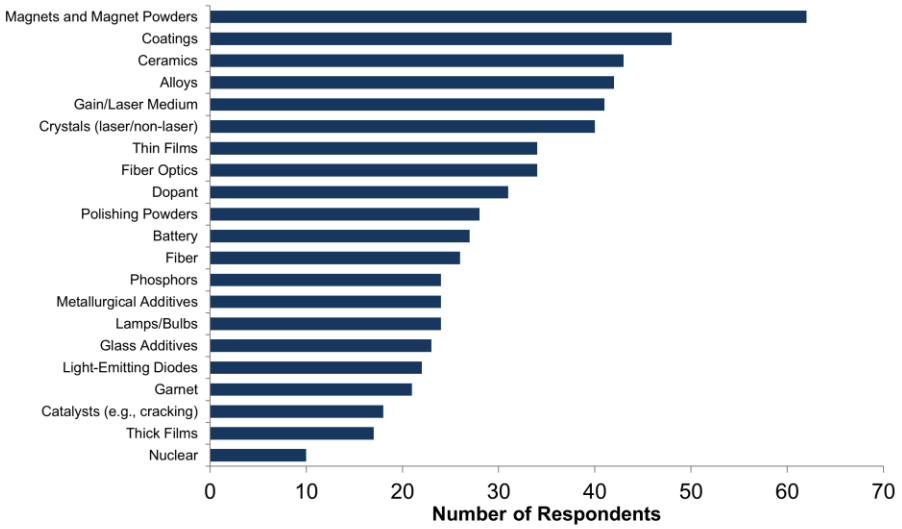
Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

On average, respondents worked with 6.3 different REEs, though half reported working with four or fewer. Seven respondents worked with all 17 elements, and another 13 worked with all but one – 'Promethium'. For the 24 respondents working with just one REE, 10 used 'Neodymium'.

Respondents were asked if they supported any of the 21 listed REE application areas listed (see Figure II-5), and identified a total of 639 applications within these categories. 'Magnets and Magnet Powders' was the application most selected, with 62 responses. Other frequently selected REE application categories included 'Coatings', 'Ceramics', 'Alloys', 'Gain/Laser Medium', 'Crystals', and 'Fiber Optics'. Forty-nine 'Other' application areas were identified by respondents, including motors, R&D, sensors, slurry, memory devices, hearing aids, and pipeline inspection.

Figure II-5: REE Application Areas

If supported by current business lines and/or current capabilities



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Respondents provided products and services in a variety of non-defense and defense market segments. Drawing from a list of non-defense market segments provided by BIS, respondents most often indicated participating in 'Research and Development', 'Aerospace', 'Optics' and 'Sensors' (see Figures II-6 and II-7). Many respondents also provided products to market segments as diverse as 'Healthcare/Medical', 'Consumer Goods', and 'Marine Transportation'.

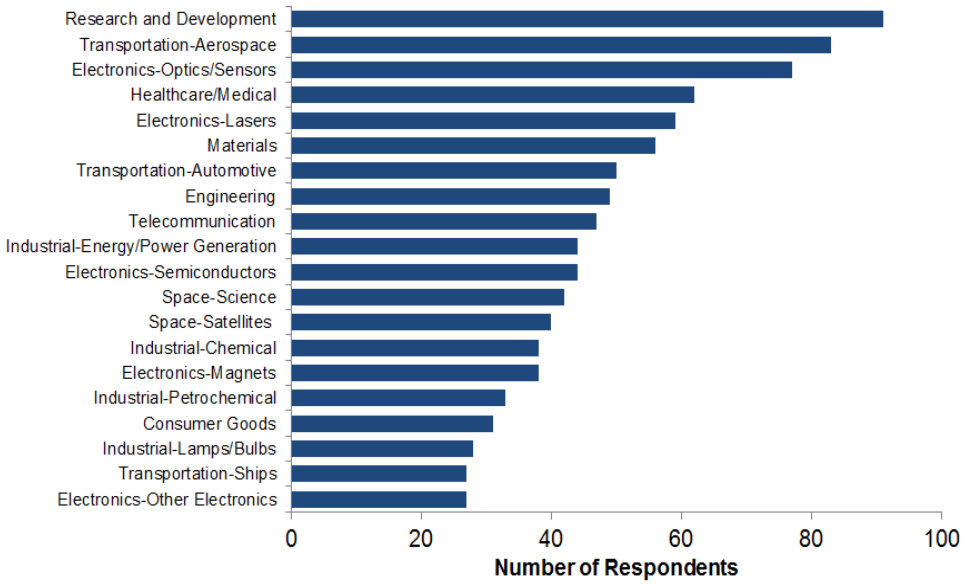
Figure II-6: Market Segments

Non-Defense			
Consumer Goods	Construction/Building	Electronics – Batteries	Electronics – Lasers
Electronics – Magnets	Electronics – Optics/Sensors	Electronics – Semiconductors	Engineering
Food/Agriculture	Healthcare/Medical	Industrial – Chemical	Industrial – Energy
Industrial – Flares	Industrial – Lamps/Bulbs	Industrial – Petrochemical	Marine Technology
Materials	Research & Development	Telecommunications	Transportation – Aerospace
Transportation – Automotive	Transportation – Ships	Transportation – Rail	Space – Launch
Space – Satellites	Space – Science	Other	

Defense			
Aircraft	C4ISR	Electronics	Energy
Ground Vehicles	Missiles	Research & Development	Ships (surface and underwater)
Space	Other		

Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

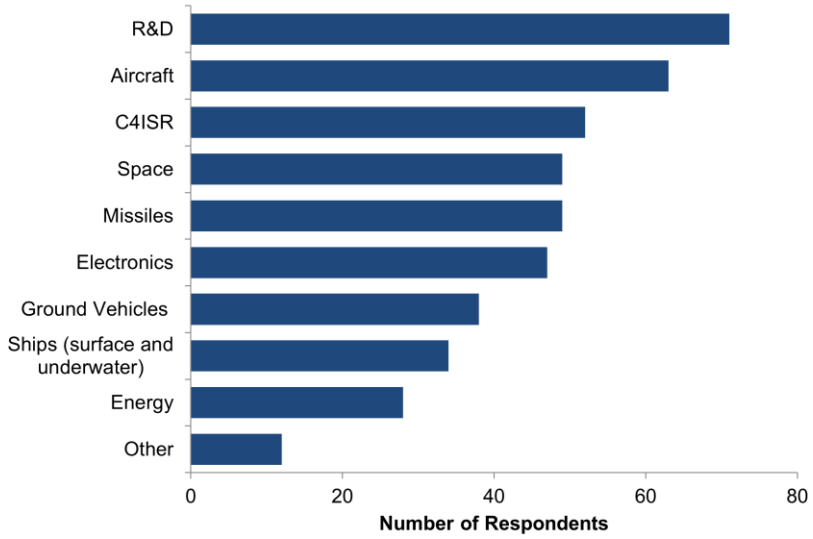
Figure II-7: Top Non-Defense Market Segment REE Participation



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

One hundred twelve respondents (70 percent) indicated that they participated in defense-related market segments (see Figure II-8). Within the defense sector, 'R&D' was the most commonly reported market segment, with 71 respondents (44 percent) participating. 'Aircraft' and 'C4ISR' (Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance) were the defense-related sectors with the second and third most common participation by respondents.

Figure II-8: Top Defense Market Segment REE Participation



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

The 160 respondents reported operating 396 facilities in 38 states (288 facilities) and 33 non-U.S locations (108 facilities) between 2010 and 2013. Respondents listed 45 facilities in California, 26 facilities in New Jersey, and 21 in New York. For the 108 facilities that were owned but not operated in the United States, the majority were located in China (20), Germany (15) the U.K. (10), France (6), and Canada (6).

BIS asked respondents to identify all REE-utilizing facilities in which they anticipated significant changes in operations from 2014 to 2018 and to explain these changes. Twenty-five organizations expected changes to 37 facilities, with many changes involving expansion of their current operations. Twenty-two respondents planned to prepare for increased business. The top locations for anticipated expansion were California, Arizona, Colorado, Montana, New York, Wisconsin, and Wyoming. Six expected to close or relocate; one of these specifically cited Chinese market control as a reason explaining, "[We] have mothballed our recycling of REE due to Chinese pricing in the market place of both phosphors and rare earths. Recycling of waste phosphors is not justified financially at this point in time, due to market conditions."

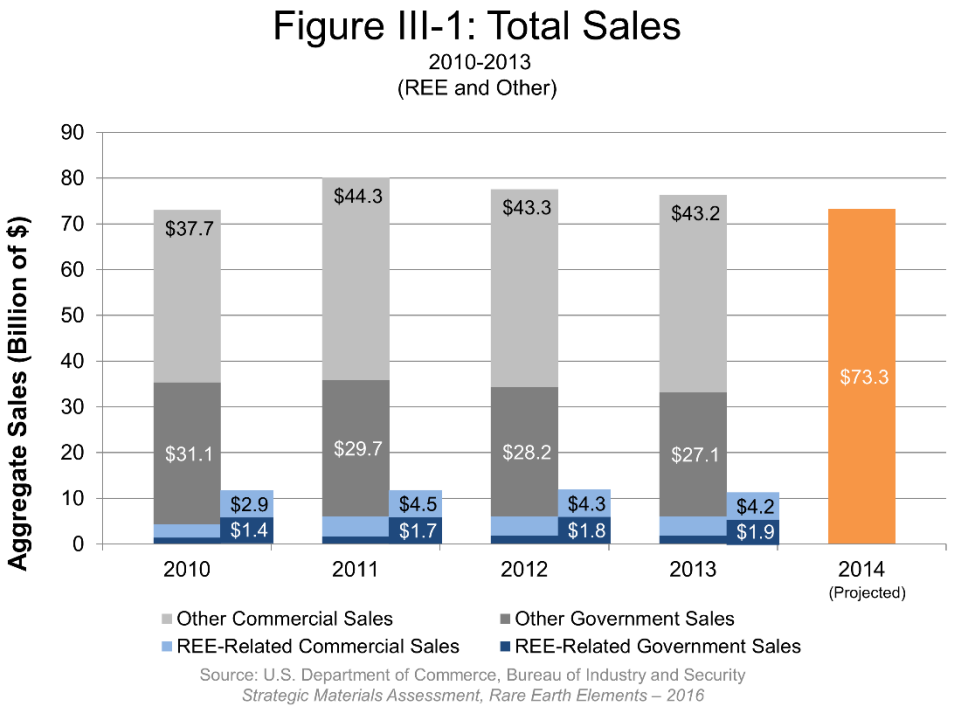
III. SALES AND FINANCIAL PERFORMANCE

Sales and other financial data were a key factor in understanding the respondents' strengths and vulnerabilities in the global REE marketplace. BIS asked respondents to provide sales and financial information for 2010 to 2013, with a special focus on REE-related sales. Sales data included transactions made to commercial and U.S. Government customers.

BIS developed a financial risk metric for the respondents, based on financial data and qualitative methods. This financial risk overview allowed BIS to batch respondents based on financial performance, providing additional insight into potential repercussions of financial impacts across the REE supply chain.

Sales

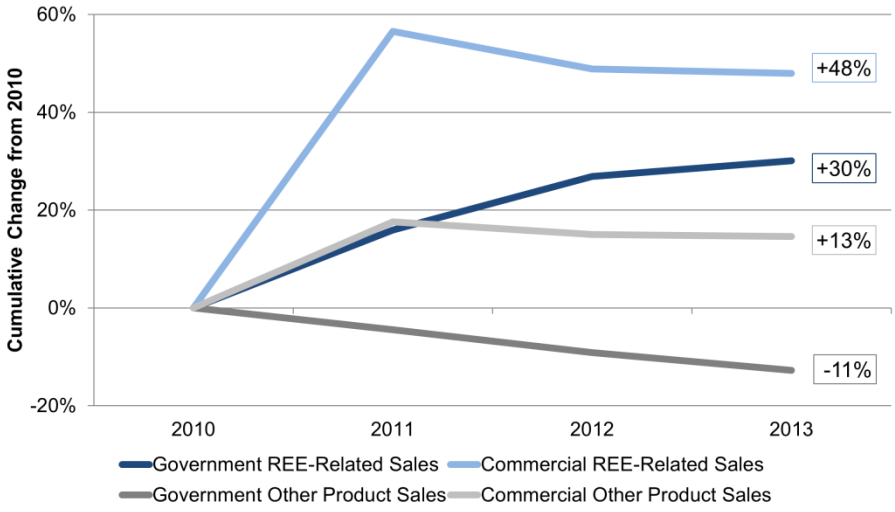
Respondents' total sales rose from $73.1 billion in 2010 to $76.4 billion in 2013 with a peak of $80.2 billion in 2011. The vast majority of these sales came from non-REE-related products. Government and commercial REE-related products accounted for only 8.0 percent of total sales in 2013, or $6.1 billion (see Figure III-1). The share of REE-related products made up an increasing percentage of total sales, rising from 5.8 percent in 2010 to 8.0 percent in 2013.



Respondents were asked to break out both REE-related commercial sales and REE-related U.S. Government sales from their total sales. Data showed that sales growth of REE-related products outpaced those of non-REE products, both for government sales and commercial sales (see Figure III-2). Commercial REE-related sales grew 48 percent from 2010-2013, while U.S. Government REE-related sales grew about 30 percent. Sales of non-REE products to the U.S. Government was the weakest category, falling consistently from 2010 to 2013 (11 percent).

Figure III-2: Change in REE- Related Sales vs. All Other Sales

Aggregate Sales Data from base year 2010

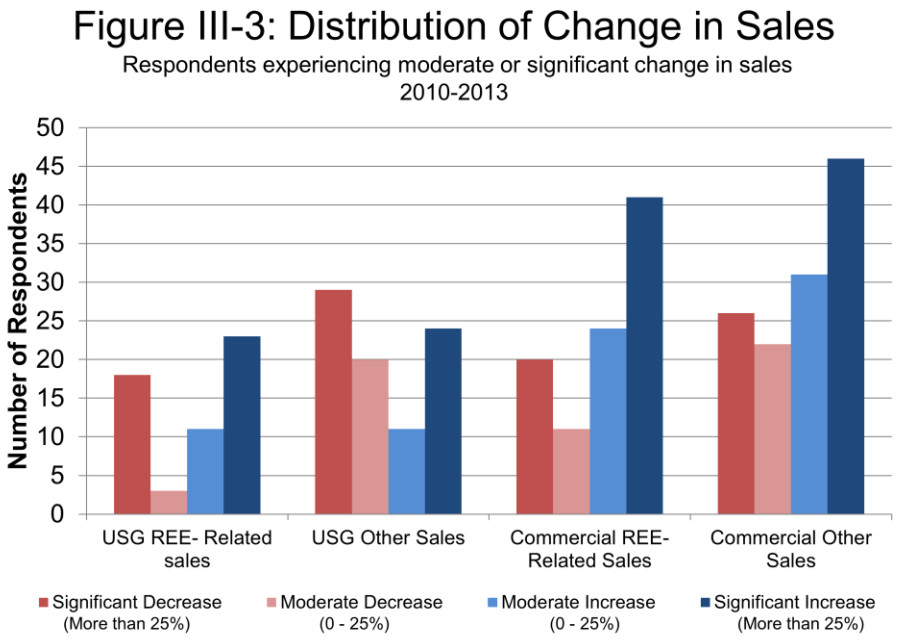


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

There was significant variability in sales performance between individual respondents. Forty-seven respondents reported that their sales decreased from 2010 to 2013, 30 of which experienced a significant decrease in sales (a drop of more than 25 percent). Respondents with declining sales over the period were of all sizes, but nearly half were smaller organizations; 44.7 percent were categorized by BIS as small companies (less than $25 million in average annual sales).

Just over one-third of the 61 respondents with REE-related U.S. Government sales reported decreased government sales from 2010-2013, with 18 of these respondents experiencing significant declines. Commercial REE-related sales had the strongest growth of all the categories, with nearly 71 percent of respondents reporting increases in this type of sale and

nearly half (48 percent) reporting significant sales growth (over 25 percent) from 2010 to 2013 (see Figure III-3).



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Financial Risk

Respondents provided data on select financial accounting items, including net and operating income, assets, liabilities, and inventories. BIS used this financial data and developed a customized financial risk metric to better capture the overall financial condition of respondents. The model was based largely on standardized financial ratios covering profitability, liquidity, leverage, and default probability of the organizations over time. Additional select qualitative data were taken into account during the financial risk evaluation.

Respondents were assigned both yearly financial risk scores as well as a more comprehensive 2010-2013 financial risk score, which incorporated yearly scores and trends in financial health.

Based on this scorecard, respondents were categorized as low/neutral risk, moderate/elevated risk, or high/severe risk. Some respondents did not have data for all years or all measures and as a result could not be assigned a financial risk score. These respondents are included in the low/neutral risk category.

For the four year period, BIS categorized three respondents as being at high/severe financial risk, with an additional 36 at moderate/elevated financial risk. The yearly financial evaluation of respondents deteriorated moderately across the period, with the number of respondents categorized as low/neutral risk on an annual basis falling from 136 to 121 companies (85 percent to 76 percent of respondents) during the 2010-2013 period (see Figure III-4A). Moderate/ elevated risk companies grew from 22 to 35 companies (14 to 22 percent of respondents) during the same timeframe. Fifteen respondents were labeled as moderate/elevated risk throughout the entire 2010-2013 period. Half of these respondents had negative profits in 2013, and 11 had negative cumulative earnings for the four-year period.

While organizations of all sizes were found in the low/neutral financial risk category, small businesses were proportionally more represented in the moderate/elevated risk and high/severe risk categories. For example, the three companies categorized as high/severe risk for the period as a whole were all small businesses. Twenty-one of the 36 total companies (58 percent) labelled as moderate/elevated risk were small businesses (see Figure III-4B)

Figure III-4: Financial Risk Ratings

A: Annual Financial Risk Ratings

	2010	2011	2012	2013
Low/Neutral Risk	136	141	125	121
Moderate/Elevated Risk	22	15	32	35
High/Severe Risk	2	4	3	4

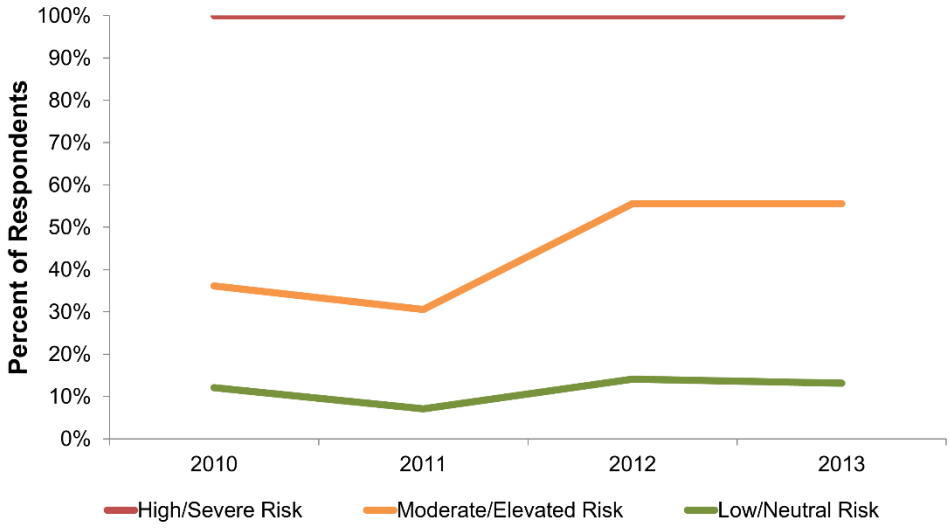
B: Full Period Financial Risk Ratings by Respondent Size

	No Sales	Small	Medium	Large	Very Large	Total
Low/ Neutral Risk	19	50	21	22	9	121
Moderate/Elevated Risk	2	21	7	5	1	36
High/Severe Risk	0	3	0	0	0	3
Grand Total	**21**	**74**	**28**	**27**	**10**	**160**

Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Respondents operating with a net loss were more likely to be identified by BIS as having high/severe financial risk. All of the respondents in the high/severe risk category operated at a net loss across each year of the 2010-2013 period. The percentage of respondents in the moderate/elevated risk category operating at a net loss grew from 36 percent to 56 percent over the period. Between 12 and 14 percent of respondents in the low/neutral risk category were operating at net loss (see Figure III-5).

Figure III-5: Percent of Respondents Operating at Net Loss by Financial Risk

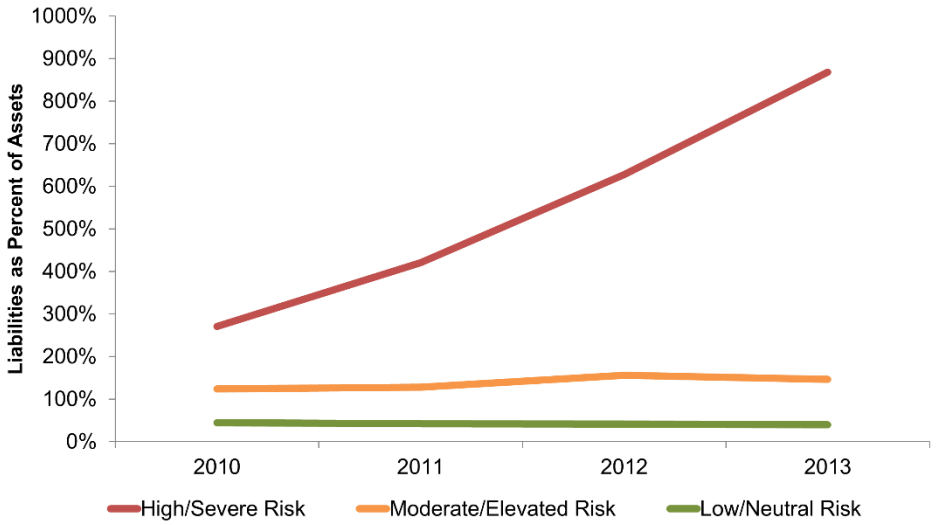


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

In addition to falling profits, respondents at moderate/elevated or high/severe financial risk generally had a higher and increasing debt burden (see Figure III-6). The average debt ratio of respondents in the high/severe financial risk category more than tripled from 271 percent in 2010 to 868 percent in 2013. The average debt ratio of respondents in the moderate/elevated financial risk category grew from 124 percent to 146 percent, and the average debt ratio of respondents in the low/neutral risk category decreased from 44 to 39 percent.[5]

[5] Debt ratio is configured based on the total debt to total assets percentage. Respondents were placed in a financial risk category of either high/severe risk, moderate/elevated risk, or low/neutral risk based on the level of operational net loss.

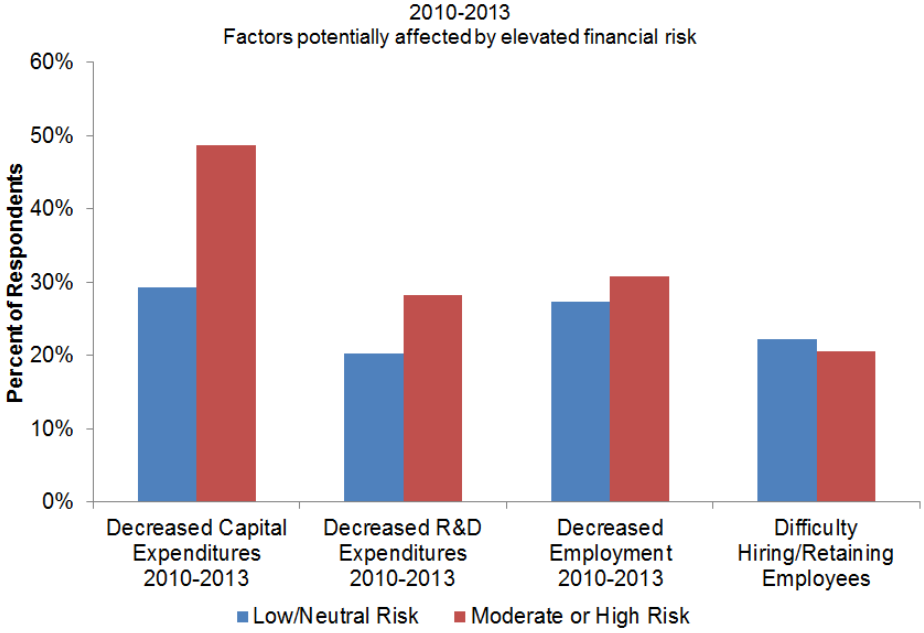
Figure III-6: Average Debt Ratio
by Financial Risk Rating



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Elevated financial risk had several potential adverse effects on how businesses operated with regard to capital expenditures, R&D, and workforce. Respondents with elevated financial risk were more likely to have decreased capital expenditures and R&D expenditures from 2010 to 2013 and a reduced workforce over that period (see Figure III-7).

Figure III-7: Impacts of Elevated Financial Risk



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

IV. PRODUCTS AND INPUTS

In order to better understand the production capabilities of the respondents, BIS asked a series of questions about product and service lines between 2010 and 2013, with an emphasis on DENTY-related lines. Respondents were asked to detail material types, applications, product type, and market segment in which these products and services participated.

In addition to products and services, BIS sought to understand the inputs and suppliers which were utilized during production. Again, an emphasis was placed on inputs – the materials, products, and services respondents used to create their own products and services – related to DENTY lines of business. BIS asked respondents to detail input material types and supplier locations with single and sole source suppliers as a focus topic.

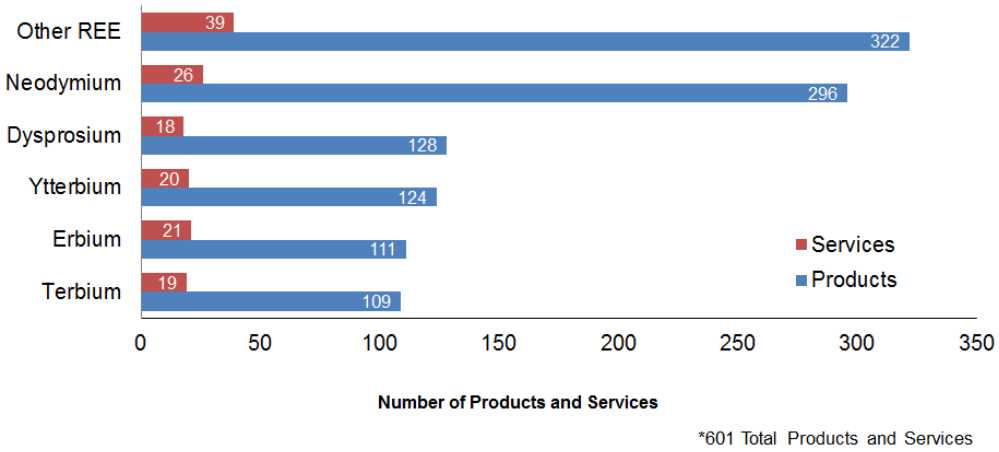
Products and Services

BIS asked respondents to list and describe their organization's products and services related to Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium (DENTY), as well as other REEs. These included finished items sold to external customers and semi-finished items produced internally for sale and/or related production purposes. The 160 respondents identified a total of 601 products or product types (see Figure IV-1)[6]. Ninety-one percent (544) of the total DENTY products and services listed were products. Neodymium and 'Other REE' were the elements most cited, with 322 and 361 products and services, respectively.

[6] Respondents were able to group together products with the same input components and similar end uses as the same basic product type

Figure IV-1: REE Products and Services

Semi-finished/Finished items and services related to DENTY*

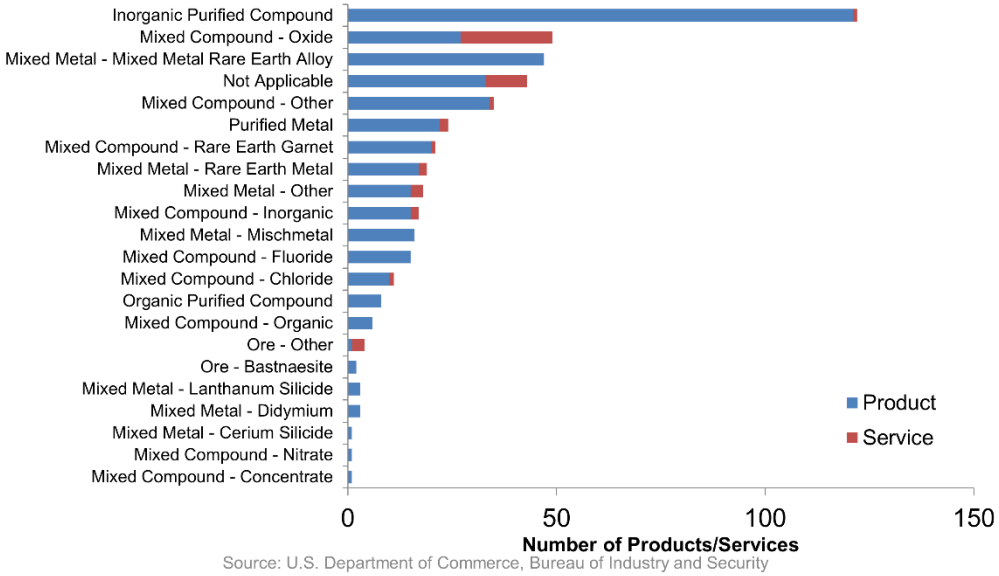


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Respondents were asked to describe the type of product or service that their organization provided. The most common DENTY-related products were Inorganic Purified Compounds, with 121 products listed by a total of 19 respondents (see Figure IV-2). Eighteen respondents provided Mixed Compound – Oxides, but they listed fewer than half as many products/services within that category. The vast majority of respondents provided just one material type.

Figure IV-2: REE Product and Service

By Ore/Compound/Material Type



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Half of all listed products/services involved the use of more than one REE. Neodymium and Dysprosium were the DENTY elements most commonly present in multi-REE products. For example, of the 146 products produced containing Dysprosium, 124 (85 percent) also contained Neodymium. Of the 144 products produced containing Ytterbium, 97 (67 percent) also contained Erbium (see Figure IV-3).

Figure IV-3: Multi-REE Use in Products

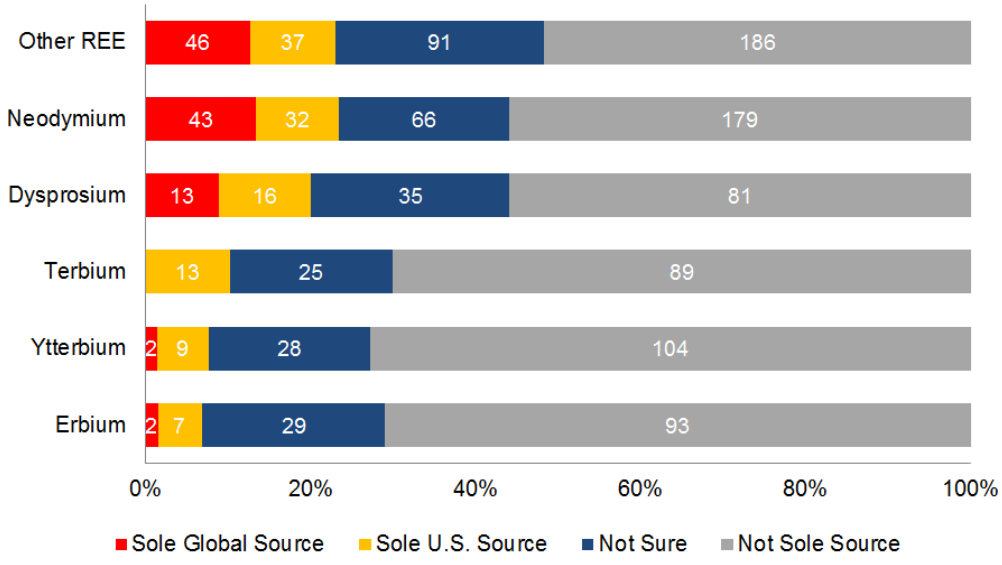
	Dysprosium	Erbium	Neodymium	Terbium	Ytterbium	Other REEs
Dysprosium	146	69	124	81	66	114
Erbium	69	132	97	68	97	95
Neodymium	124	97	322	85	92	199
Terbium	81	68	85	128	68	94
Ytterbium	66	97	92	68	144	95
Other REEs	114	95	199	94	95	361

Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

BIS asked respondents if they believed their organization was a sole source for the REE-related products and services that they listed (U.S. or global). Thirty-eight respondents identified 120 of their products/services as sole source. These sole source products represented each of the DENTY elements, and often multiple of the DENTY elements within a single product (see Figure IV-4). For example, respondents indicated that they were the sole global source for 43 products/services containing Neodymium and the sole U.S. source for 32 products/services containing Neodymium. The highest number of both global and U.S. sole source products/services, however, were products containing at least one of the 12 non-DENTY REEs.

Figure IV-4: Sole Source Products/Services

Respondents providing products believed to be sole source – U.S. and global



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Respondents also indicated the primary end-use application for each of their products/services (see Figure IV-5). 'Magnets and Magnet Powders' were the most common material application, with 115 products/services listed by respondents (see Figure IV-6). 'All Other' material applications constituted the second largest category, with 90 products identified by respondents.

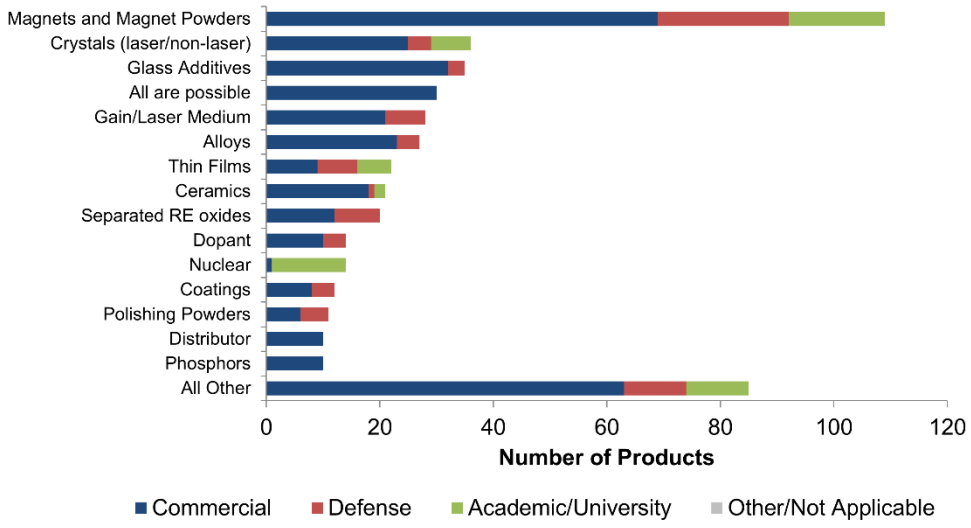
Responses for each material application were also divided by the organization type supported. A majority of respondents supported Commercial markets across all material applications. Products and services for Defense usage were focused primarily on 'Magnets and Magnet Powders', 'Separated RE Oxides', and 'Gain/Laser Medium' applications. Among products/services primarily used by Universities, 'Magnet/Magnet Powders' and 'Nuclear' applications were most frequently identified.

Figure IV-5: REE Primary Material Applications

Alloys	Battery	Carbon Arc Electrodes	Catalysts	Cathode Ray Tubes
Cement	Ceramics	Coatings	Crystals	Dopant
Fiber	Fiber Optics	Gain/Laser Medium	Garnet	Glass Additives
Klystrons	Lamps/Bulbs	Light-Emitting Diodes	Magnets and Magnet Powders	Metallurgical Additives
Nuclear	Phosphors	Polishing Powders	Thick Films	Thin Films
Traveling Wave Tubes	All Other			

Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

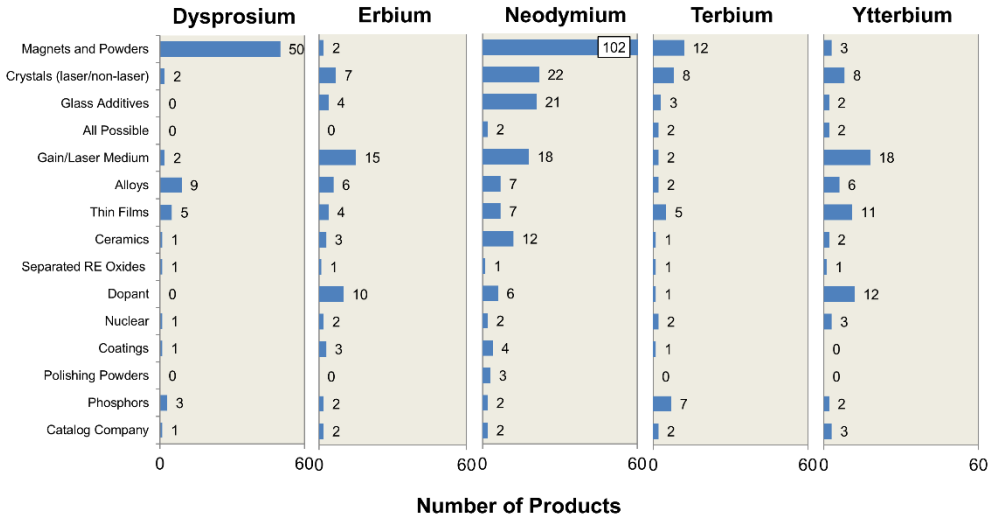
Figure IV-6: Product/Service End Use: REE Primary Material Application



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Over two-thirds of the products/services identified by respondents were related to the DENTY elements; a large portion of these products were used for 'Magnets and Magnet Powder' applications (see Figure IV-7). Neodymium was found in twice as many product applications as the next most common REE, Dysprosium. Although the DENTY elements have been grouped together as part of this assessment, they have different characteristics and end-uses. Dysprosium and Neodymium were overwhelmingly used in magnet-related applications, while Erbium and Ytterbium were more focused in laser gain materials and dopants.

Figure IV-7: Product/Service End Use: Primary Material Application by DENTY REE

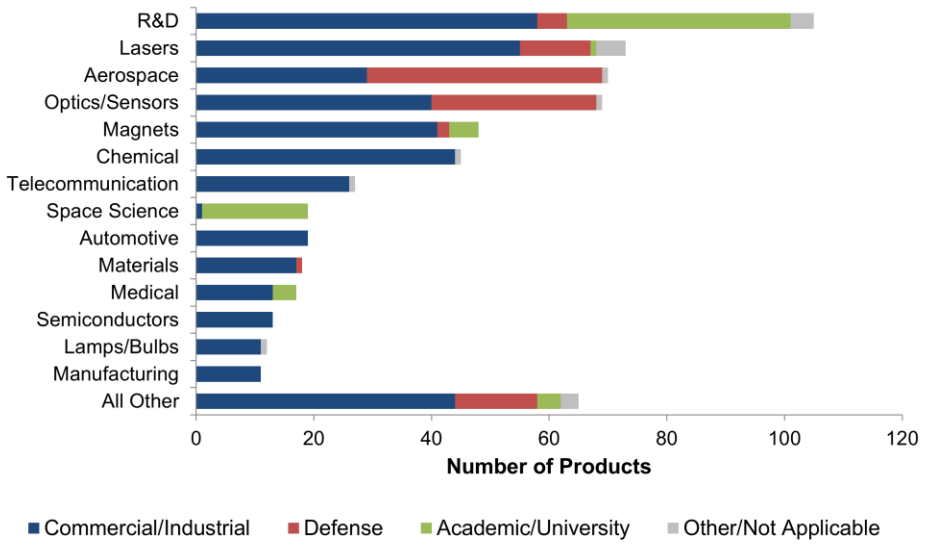


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Respondents were asked to identify the primary market segment in which their products or services were used (see Figure IV-8). 'Research and Development (R&D)' had the largest market sector participation, with 105 products/services identified by respondents, and also the greatest number expected to be used in the academic community. While the 'Aerospace' sector was third most frequently identified, it contained nearly half of the products/services with

primarily defense end-uses. The 'Optics/Sensors' sector also contained a high number of products/services with defense end-uses.

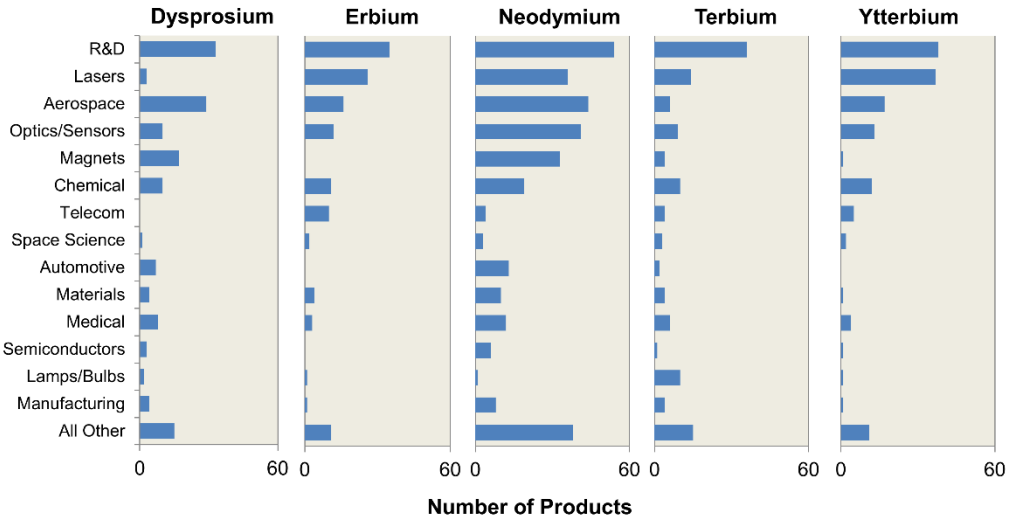
Figure IV-8: Product/Service End Use: Primary Market Segment



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

As with the end-use applications of the DENTY products/services, there were notable differences in the end-use market segment across the elements. The R&D market segment contained the most DENTY specific products and services (see Figure IV-9). Neodymium-based products and services, in addition to being the most prevalent overall, also exhibited the widest array of market segment uses. Erbium and Ytterbium containing products tended to be more heavily destined for the laser market, as well as aerospace and optics/sensors, with little usage in many of the other market segments.

Figure IV-9: Product/Service End Use:
Primary Market Segment by DENTY REE



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

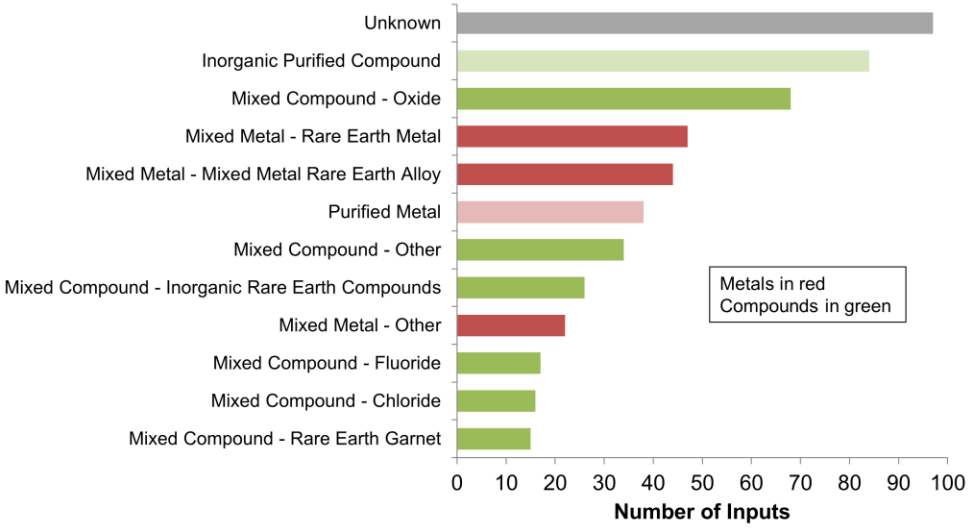
Inputs and Suppliers

In order to understand more about the inputs used by respondents to create their products, especially with regards to their REE-related business lines, BIS asked respondents to provide details of their inputs and suppliers. Respondents identified 618 inputs from as many as 376 unique suppliers for business lines related to DENTY.[7] Respondents specified 21 different input types, including different types of mixed compounds, mixed metals, and purified compounds in addition a small number of raw ore inputs and inputs of unknown material type. One hundred and fifty-nine inputs were mixed or purified metals, and 277 inputs were listed as compounds (see Figure IV-10 for the most frequently identified material types).

[7] BIS consolidated the names of suppliers provided by respondents to individual organization names when possible, but some duplicate entries may remain, due to abbreviations, misspellings, and ambiguous supplier names.

Figure IV-10: Input Material Type

For REE-related Products, 2012-2013

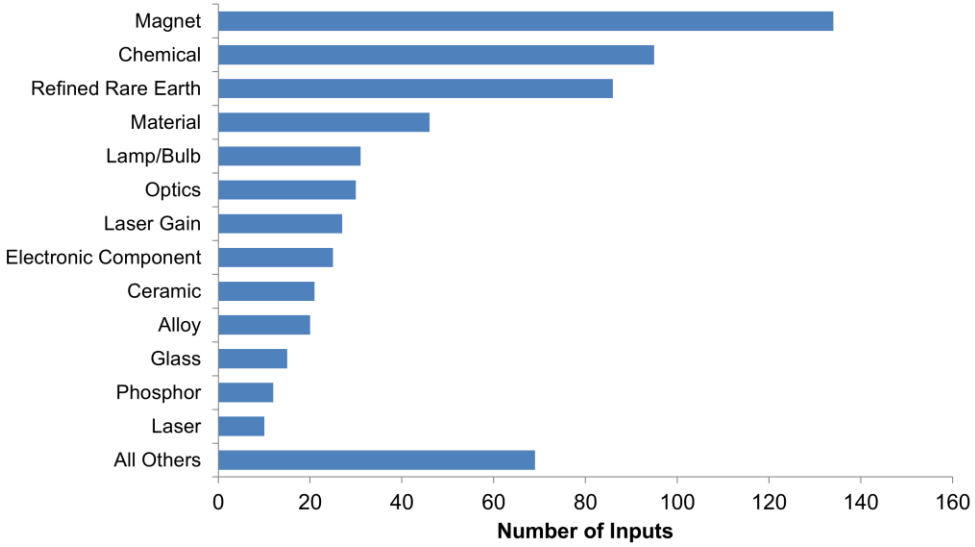


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Inputs were grouped into categories of 21 input types—the same types used in listings of their own products/services. As with products/services, magnets and chemicals were the most prevalent types, but more basic materials like Refined Rare Earth and Material were much more commonly identified as input types than as respondents' product types. This is because manufacturers used these inputs to formulate more finished products (see Figure IV-11).

Figure IV-11: Input Types Used

For REE-related Products, 2012-2013

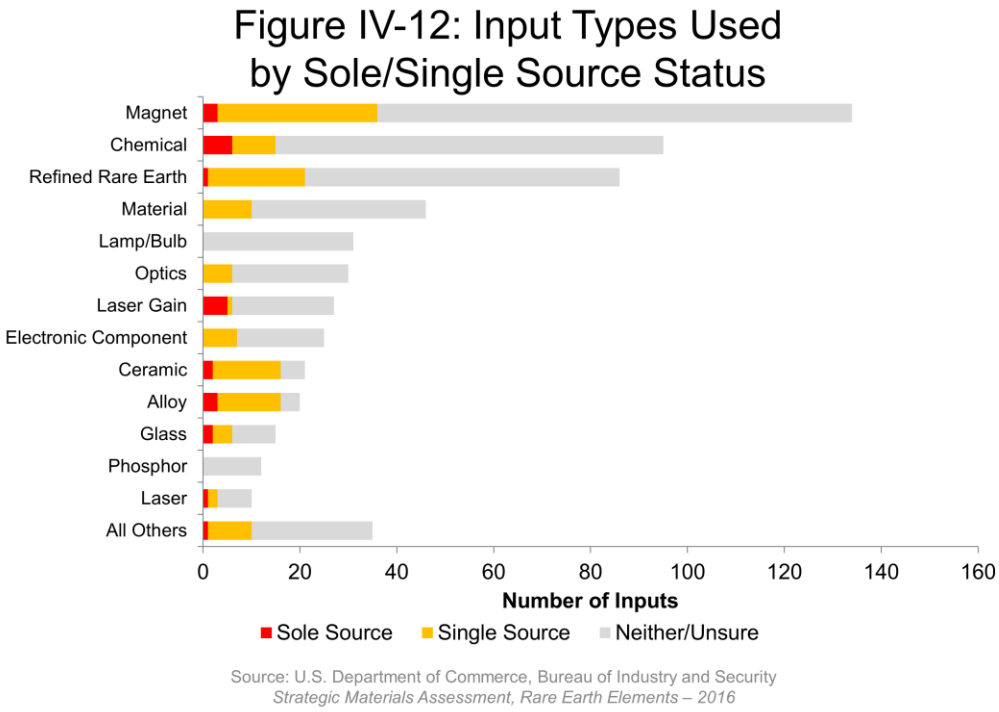


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

For each of their suppliers, respondents indicated if the supplier was a single source or a sole source. A single source supplier is an organization that is designated as the only accepted source for the supply of parts, components, materials, or services, even though other sources with equivalent technical know-how and production capability may exist. A sole source supplier is an organization that is the only source for the supply of parts, components, materials, or services. In the case of a sole supplier, no alternative U.S. or non-U.S. based supplier exists other than the current supplier.

Respondents listed 24 inputs with sole source suppliers and 128 inputs with single source suppliers. Ten of the listed sole source suppliers (42 percent) and 68 of the listed single source suppliers (53 percent) were located in the United States. Chemicals and Magnets had the greatest number of sole source and single source inputs, respectively (see Figure IV-12). On a percentage basis, over three-quarters of Alloy and Ceramic inputs were sole or single source,

which was by far the greatest proportion. Just two input types had no known sole or single source suppliers listed, Lamps/Bulbs and Phosphors.

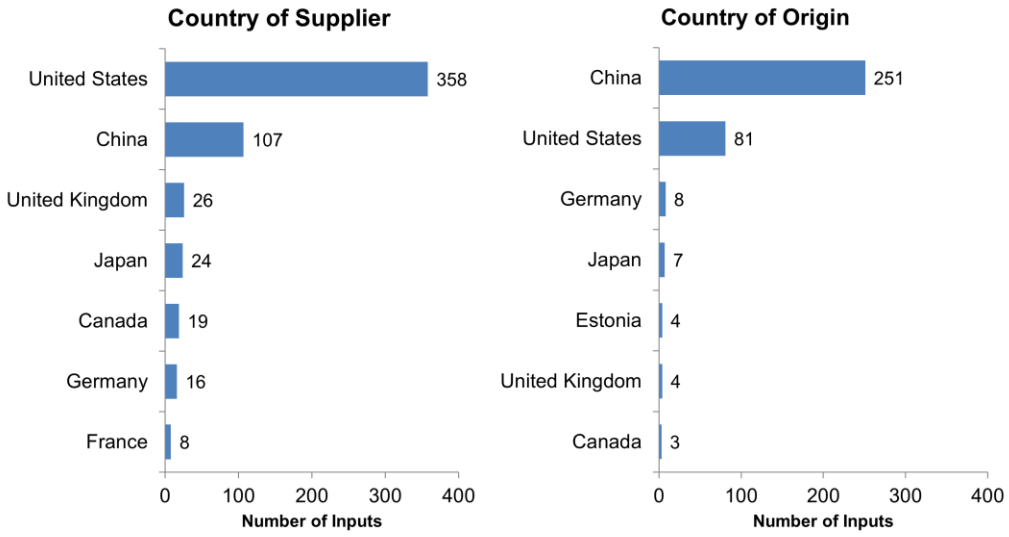


In order to better understand the international market for DENTY-related inputs and suppliers, BIS asked respondents to provide the location of their suppliers and the original source country of the REE, if known, between 2012 and 2013. For both measures of REE source, the United States and China were by far the leading sources (see Figure IV-13). Of the 26 total supplier countries listed, the United States was the largest direct supplier of REE-related inputs with 358 inputs identified, followed by China with 107 inputs identified. In terms of county of origin for REE-related inputs, respondents were able to identify the primary country of origin for 368 inputs. REEs originating from China represented roughly two-thirds of these inputs, with those from the United States accounting for another 22 percent. All remaining countries accounted for

just under 10 percent of known origin REEs, with no single country accounting for more than eight inputs.

Figure IV-13: Countries Providing Inputs

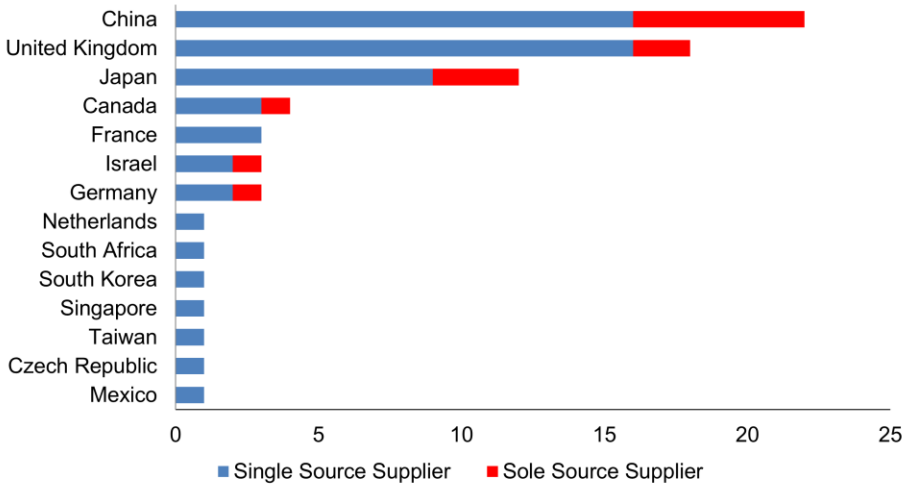
Supplier and Origin, 2012-2013



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

China, the largest non-U.S. supplier overall, was also the largest non-U.S. supplier of sole and single source inputs with 16 inputs listed as single source and six inputs listed as sole source (see Figure IV-14). Suppliers from the United Kingdom and Japan accounted for the next most common sole and single source inputs. Suppliers from these countries, on a percentage basis, were far more likely to be sole or single source suppliers with 69 percent of U.K. suppliers identified as sole or single source, as with half of Japan-based suppliers compared to 21 percent of suppliers from China.

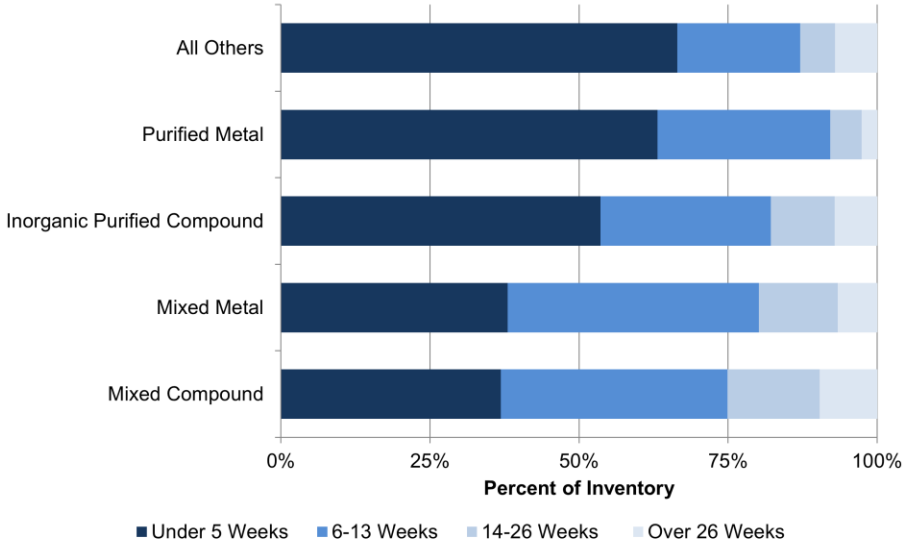
Figure IV-14: Single and Sole Source Foreign Suppliers to U.S. Companies



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

On the whole, respondent inventories were limited with more than half of all inputs having five or fewer weeks of supply. Just seven percent of inputs were kept in inventory for longer than six months and 11 percent for between three and six months. Inventory turnover was slowest in Mixed Compounds with 25 percent of inputs maintained for more than 13 weeks and 63 percent for more than five weeks (see Figure IV-15). A significant share of these inventory levels are due to Oxides, for which 40 percent of inputs were maintained for more than 13 weeks.

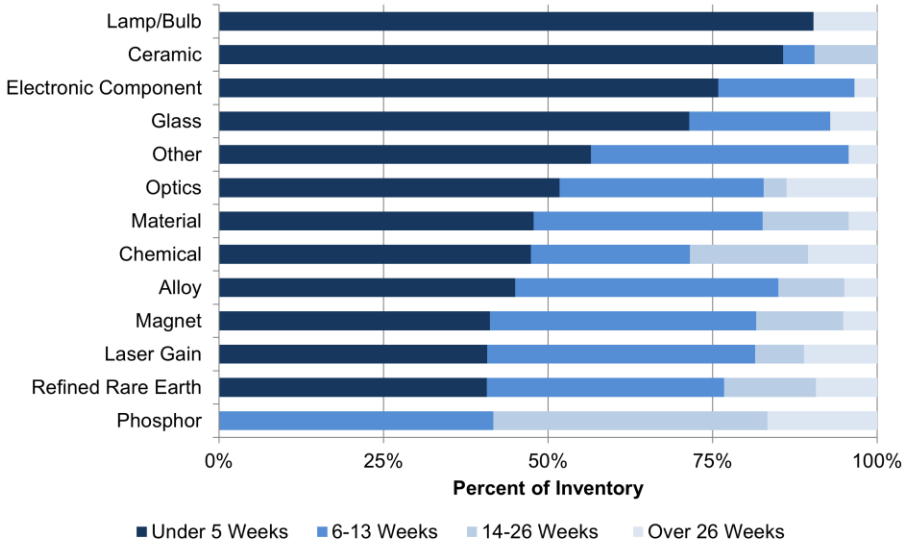
Figure IV-15: Weeks of Inventory Supply by Material Type



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

For several input types – Lamps/Bulbs, Ceramics, Electronic Components, and Glass – nearly all inputs were kept in inventory for under five weeks (see Figure IV-16). Many of the more basic materials, including Refined Rare Earths, Chemicals, and Alloys, tended to have larger inventory levels with most inputs remaining in inventory 6-13 weeks or longer.

Figure IV-16: Weeks of Inventory Supply by Input Type

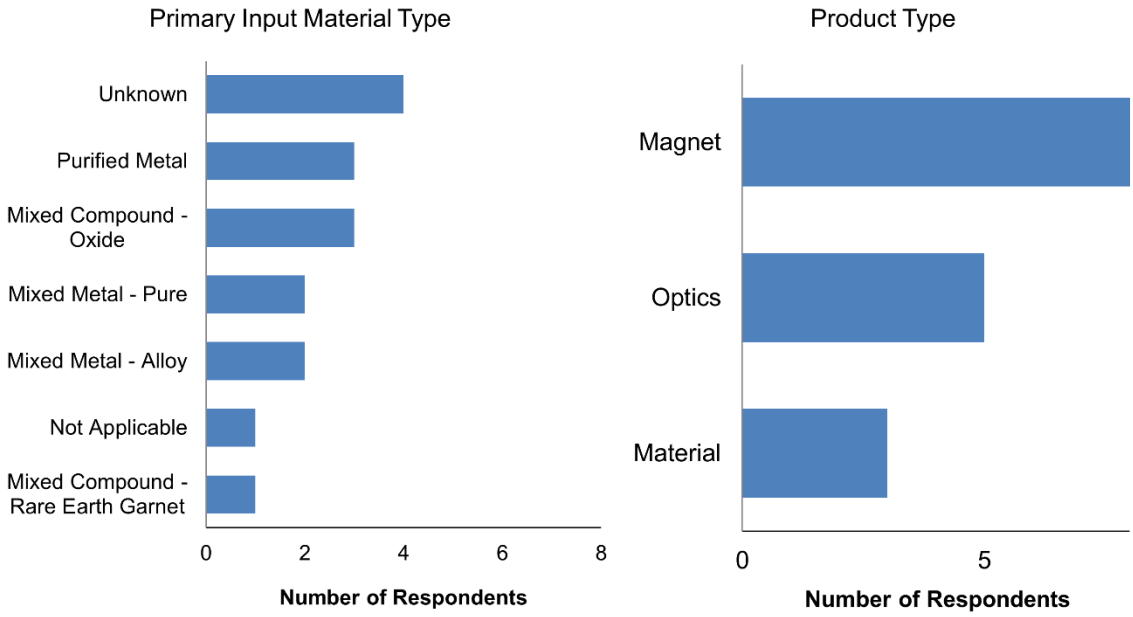


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Supply chain disruptions were only a minor issue for respondents from 2012 to 2014. Seven respondents reported 16 total supply chain disruptions (see Figure IV-17). Eleven of these disruptions were for suppliers located in China. China was the original source of REE for all 16 of the supply chain disruptions. The reasons given for disruptions varied, including legal holdups, quality issues, and significant price increases. One respondent commented that "price increases of 500 percent stopped production" of their terbium-based inputs.

Figure IV-17: Inventory Supply Disruptions

2012-2014



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

V. Organizational Challenges, Competitiveness, and Capital Expenditures

BIS asked a series of questions about the organizational challenges and the future outlook of the respondents in order to better understand the issues they are confronting and the impact on their REE-related business lines. The respondents also detailed actions and potential actions that could be taken to make their businesses more competitive. Due to the recent volatility in the REE market, special attention was paid to REE availability and other supply chain issues that may affect an organization's competitiveness. Finally, BIS sought to understand respondents' capital expenditures and perceived obstacles to expanding REE-related business lines.

Organizational Outlook and Challenges

BIS provided a list of 30 potential organizational challenges (including an 'Other' category). Respondents were asked to identify those impacting DENTY-related operations from 2010 to 2013 and those expected to impact DENTY-related operations in the future (see Figure V-1). Respondents also ranked the top five issues affecting their DENTY-related operations and provided narrative explanations for each.

Figure V-1: Organizational Challenges

Complete list of business challenges provided in survey

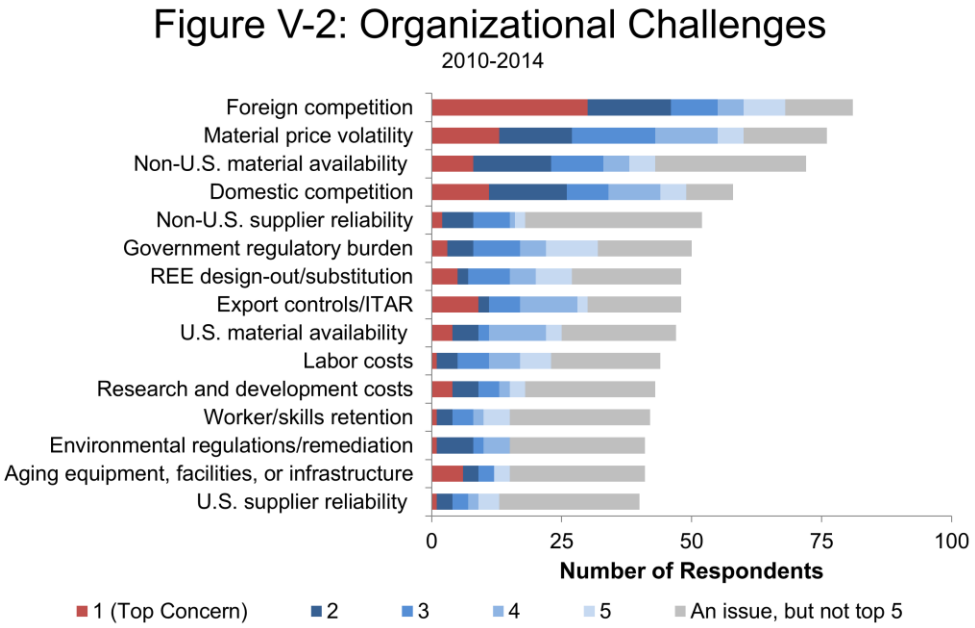
Aging equipment, facilities, or infrastructure	Availability of capital	Domestic competition
Environmental regulations/remediation	Export Controls/ITAR	Foreign Competition
Government purchasing volatility	Government regulatory burden	Healthcare
Illegal rare earth mining/smuggling	Labor availability	Labor costs
Material price volatility	New production methods	Non-U.S. material availability
Non-U.S. supplier reliability	Patent infringement	Pension costs
Proximity to customers	Proximity to suppliers	Reduction in U.S. Government demand
REE design-out/substitution	Qualification/certifications	Quality of inputs
Research & development costs	Taxes	U.S. material availability
U.S. supplier reliability	Worker/skills retention	Other

Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

For all respondents, each challenge on the list was selected as a top five concern at least once. 'Foreign Competition' was overall the most commonly selected challenge, with 81 respondents (51 percent) reporting that foreign competition was an issue between 2010 and 2013 (see Figure V-2). Over twice as many respondents selected 'Foreign Competition' as their top challenge than any other issue. Respondents were particularly concerned with Chinese competition; one respondent commented, "Chinese competition for both [Neodymium Iron Boron] (NdFeB) alloy and for NdFeB magnets has shut down several magnet customers in the U.S. over the past 15 years and has inflicted serious financial damage to all NdFeB alloy producers outside China."

'Material Price Volatility' was the second most selected organizational challenge, with 76 respondents (48 percent) reporting it as an issue. As with foreign competition, China was a major concern, with several respondents noting sudden Chinese export quota changes in the past and fear of additional changes in the future. One issue of note was 'Non-U.S. Supplier

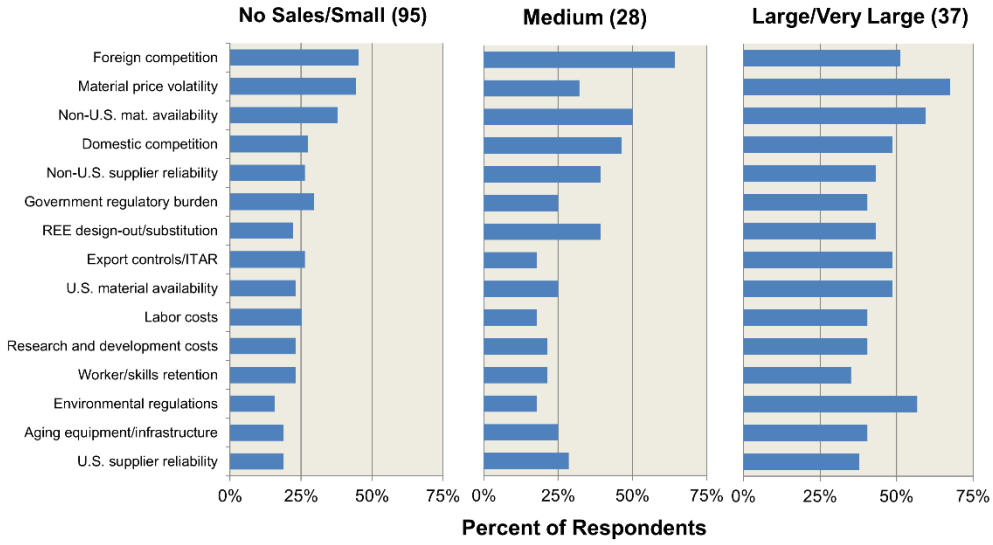
Reliability,' which was the fifth most identified challenge overall, but was not frequently cited as one of the top five challenges.



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Respondents of different sizes exhibited some variation in the types of challenges they were most concerned about. Larger respondents tended to identify more challenges in general, listing and average of 10 organizational challenges, compared to seven for medium organizations and six for small organizations. Larger respondents were comparatively more concerned about 'Material Price Volatility' and 'Environmental Regulations', while smaller respondents reported comparatively outsized concern about 'Government Regulatory Burden' (their fourth most frequent concern), 'Export Controls/ITAR', and 'Labor Costs' (see Figure V-3).

Figure V-3: Top Organizational Challenges by Organization Size



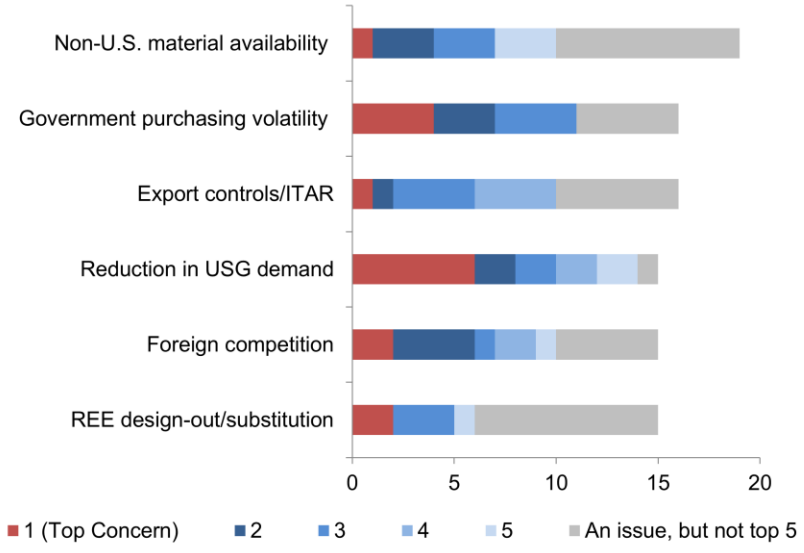
Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

The top five organizational challenges remained remarkably consistent across respondents participating in mid- and later stages in the value chain. Organizations participating in Refining, Processing, Metallurgy, Manufacturing, Distribution, Recycling, Substitution, R&D, or End-Use all ranked the same organizational challenges. Respondents participating in earlier steps of the supply chain – Financing, Exploration, and Extraction – included other challenges in their rankings. Examples of these additional organizational challenges include 'Illegal Rare Earth Mining/Smuggling' and 'Availability of Capital.'

The 35 respondents (22 percent of the total respondents) who identified their organization as dependent on sales to the USG for continued viability had top organizational challenges reflecting their USG-oriented business. For these organizations, 'Government Purchasing Volatility' and 'Reduction in U.S. Government Demand' were among the four most frequently identified challenges, and were the two most commonly listed top challenges (see Figure V-4).

Respondents dependent on the USG also exhibited concern with regard to 'Export Controls/ITAR' and 'REE Design-Out/Substitution'.

Figure V-4: Top Five Challenges for the 35 Organizations Dependent on USG Purchases

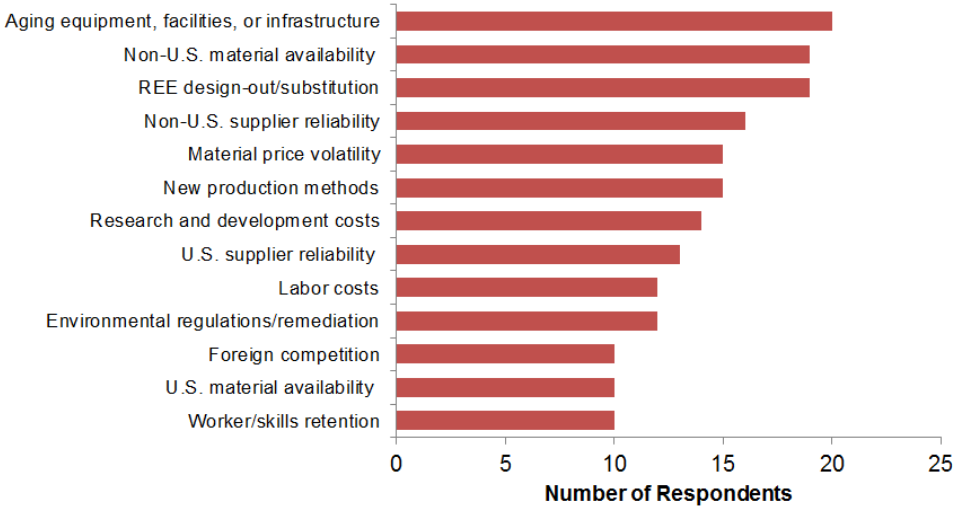


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Respondents were also asked to categorize their organizational challenges by timeframe; issues affecting their organization could be marked 'Current,' 'Future,' or 'Both.' In this way, respondents could indicate if certain challenges were expected in the future (from 2014 to 2018) that may not be impacting their organization currently. In six areas – 'Domestic Competition', 'Export Controls/ITAR', 'Government Regulatory Burden', 'Illegal Rare Earth Mining/Smuggling', 'Government Purchasing Volatility', and 'Reduction in USG Demand' – fewer respondents anticipated challenges in the future compared to current challenges. In nearly every other issue area more respondents expected current challenges to rise in the future.

The difference between current and future expectations was especially notable for 'Aging Equipment, Facilities, or Infrastructure' and 'REE Design-Out/Substitution' (see Figure V-5). These two areas had both the highest number of respondents indicating they would be future-only challenges, as well as the highest differential between 'future-only' and 'current-only' selections. 'Aging Equipment, Facilities, or Infrastructure' was the only issue area for which as many respondents selected 'future-only' as selected 'current-only' and 'both current and future' combined.

Figure V-5: Organizational Challenges Expected to Increase in the Future
2014-2018



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

In addition to asking respondents to report challenges to their organizational viability, BIS provided respondents with an opportunity to request information on federal and state services aimed at helping companies better compete in the global marketplace. Sixty-three of the 160 respondents indicated they would like to receive information on at least one of the 14 assistance

areas (see Figure V-6). BIS generated bulletins covering programs from a wide variety of USG agencies, including the Small Business Administration, Department of Labor, National Science Foundation, Department of State, and several Department of Commerce agencies, such as the National Institute of Standards and Technology's (NIST) Manufacturing Extension Partnership. Respondents requested information in all topic areas, with Business Development, R&D, and Global Exporting Opportunities cited as the most common requests. Small organizations tended to be comparatively more interested in assistance with Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs and Product/Service Development, while larger respondents had comparatively more interest in Global Export Opportunities and Training Opportunities.

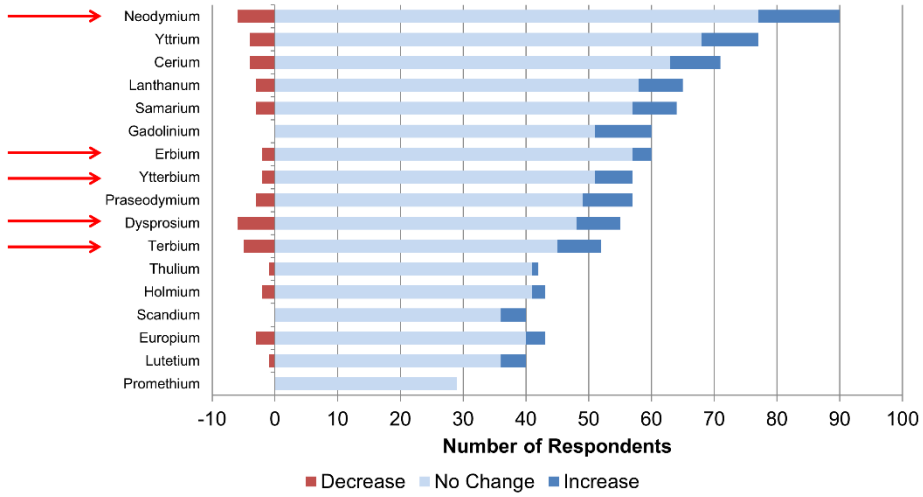
Figure V-6: Interest in USG Outreach Programs by Respondent Size

Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Competitiveness

In an effort to understand potential supply chain constraints on the industrial base, BIS asked respondents about possible changes in REE availability in the near-future. The perceived net availability of all REEs was largely stable, with most respondents expecting no change in availability between 2014 and 2016 (see Figure V-7). At least as many respondents expected increases in availability as expected decreases for every element, with the biggest differentials between increases and decreases found for Gadolinium (+9) and Neodymium (+7). The greatest volatility in expectations was for Dysprosium, where six respondents (10 percent of those providing an estimate) predicted decreased availability and seven respondents (11 percent) predicted increased availability (see Figure V-7).

Figure V-7: Expected Changes in REE Availability
2014-2016



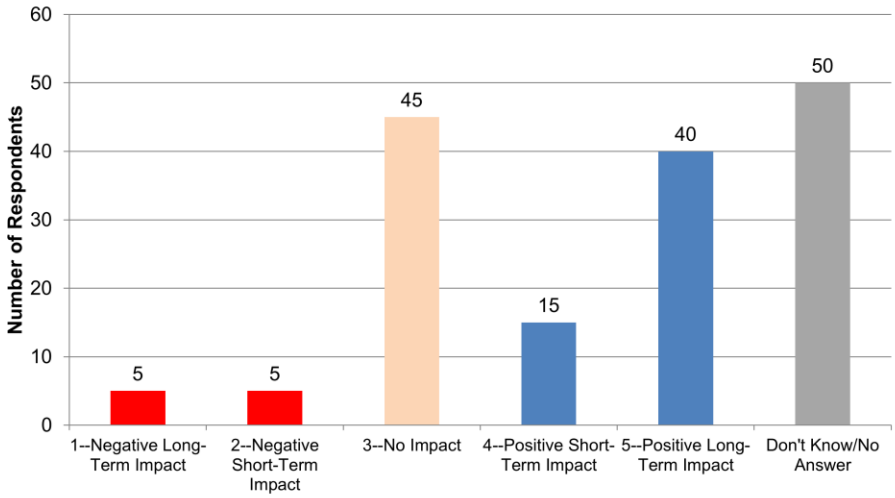
Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

BIS posed a series of hypothetical scenarios in order to better understand the organizational outlook of the respondents. Two of these scenarios focused on supply chain availability and its potential impact on organizations' REE-related business lines. Respondents were asked how a hypothetical increase in both U.S. imports and overall supply of REEs and REE-related products would affect the sustainment of their REE-related business lines. A low percentage of respondents (10 respondents in total, six percent) believed that an increase in U.S. imports and overall REE-related supply would negatively impact their REE-related business lines in the short or long term. Nearly all of these 10 respondents were suppliers of refined rare earth products or magnets. These respondents commented that an increased supply in REEs and REE-related products could cause 'price erosion in the general market' which may 'oversaturate the market' and 'reduce future investments' (see Figure V-8).

Fifteen respondents (nine percent) believe that an increased supply would have a positive short-term effect on their REE-related business lines, while 40 respondents (25 percent) believed that it would have a positive long-term effect. One respondent suggested that, "More mining means more product. This means lower material costs." In addition to several comments about lower costs, one respondent also hypothesized that, "Increased supply of REEs generally helps to spur increased demand, which is good for REE producers."

A majority of respondents believed that a hypothetical increased supply would have either no impact on their business lines (45 respondents – 28 percent) or did not know (50 respondents – 31 percent). One respondent commented, "Current global supply is sufficient to meet the organization's needs; an increase in supply will not affect this situation."

Figure V-8: Impact of an Increase in Both U.S. Imports and Overall Supply



Source: U.S. Department of Commerce, Bureau of Industry and Security
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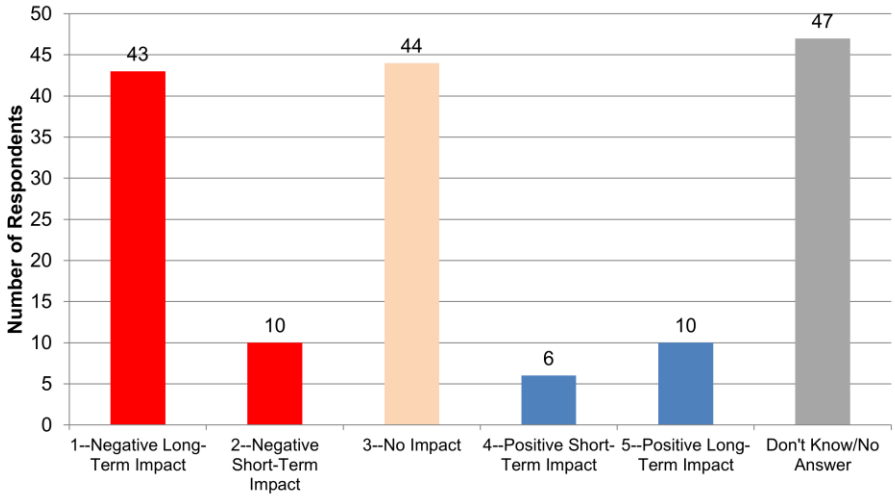
A second BIS hypothetical scenario asked if organizations' REE-related business lines would be affected by a decrease in the number of U.S. located suppliers for REEs and REE-related products. The largest percentage of respondents believed that the decrease in U.S. located suppliers would have no impact on their REE-related business lines (44 respondents – 27 percent) or did not know (47 respondents - 31 percent). A small percentage of respondents (10 percent total) believed that a U.S. based supply decrease would have either a short or long-term positive impact on their REE-related business lines (see Figure V-9).

A larger percentage of respondents believe that a decrease in U.S. located suppliers would have either a short-term (10 respondents – six percent) or long-term negative impact on their REE-related business lines (43 respondents - 27 percent). Respondents commented that, "foreign suppliers would result in higher shipping costs" and that "less overall options [could create] dependence on single source locations". Other respondents worried that a U.S. supplier decrease

would “put upward price pressures on our current suppliers” and “give China a greater monopoly”.

Figure V-9: Impact of a Decrease in the Number of U.S.-located Suppliers for REEs and REE-related Products



Source: U.S. Department of Commerce, Bureau of Industry and Security
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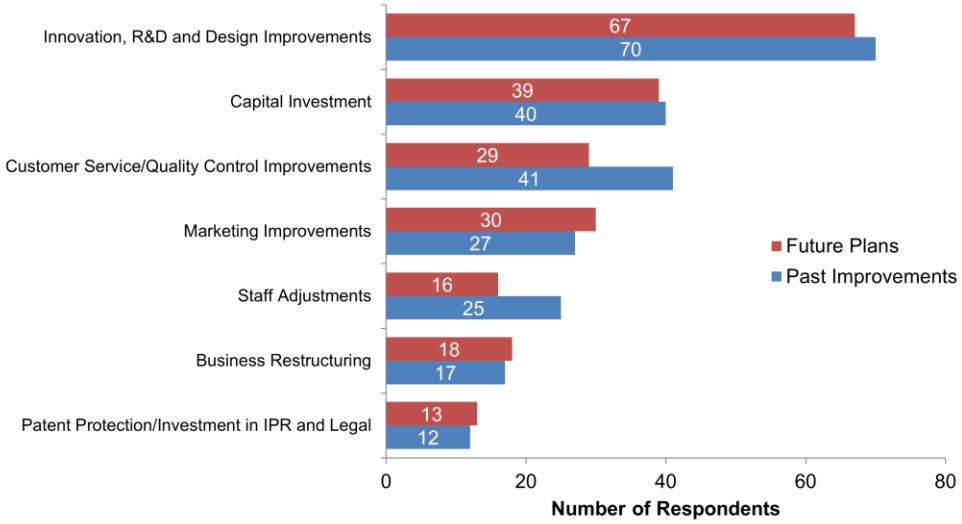
Respondents were asked to identify key actions their organizations had taken from 2010 to 2013 and were planning to take from 2014 to 2018 in order to improve their overall competitiveness. ‘Innovation, R&D, and Design Improvements’ was the highest ranked category in both past and future actions, with 70 and 67 respondents (44 and 42 percent) selecting that category. Respondents planned to emphasize ‘R&D and process development’ and to take further actions recycling REE products such as cerium polishing powder and phosphor waste. The second most frequently identified improvement category was ‘Capital Investment’, with 40 respondents (25 percent) noting it as a past action and 39 respondents (24 percent) as a future action. Actions in this category included an ‘increase of inventory of key items,’ the building of a new production

facility in the U.S., 'more sophisticated machining capabilities,' and scaling up REE production (see Figure V-10).

Two improvement areas – 'Customer Service/Quality Control Improvements' and 'Staff Adjustments' – were notable in that significantly more respondents identified this as already accomplished than planned for the future. In three areas – 'Marketing Improvements', 'Business Restructuring', 'Patent Protection/Investment in IPR and Legal' – was there a slight edge toward future improvements.

Figure V-10: Achieving Improvements to Competitiveness

Past (2010-2013) and Future (2014-2018)

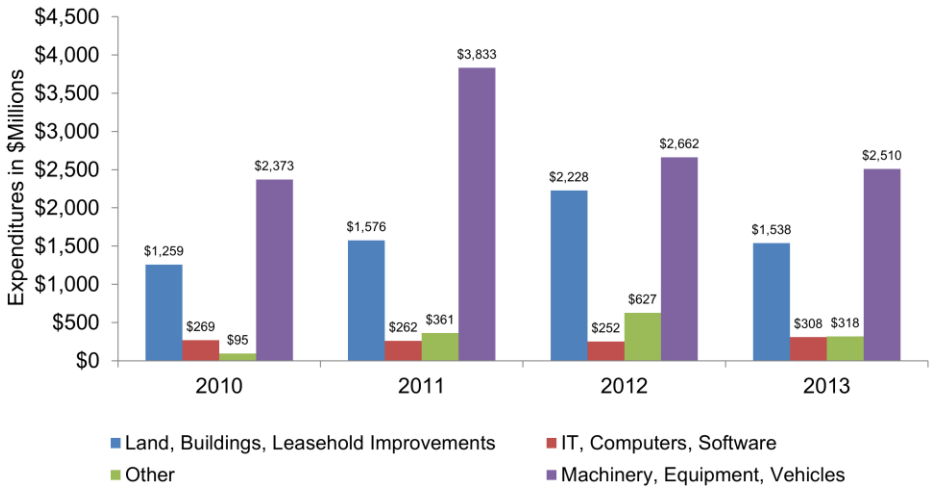


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Capital Expenditures

Aggregate capital expenditures from 2010 to 2013 were heavily directed toward investments in machinery, equipment, and vehicles. This focus on updating or upgrading production could reflect concerns about expected challenges from aging equipment, facilities, and infrastructure noted earlier. Overall capital expenditures showed no clear trend across the period 2010 to 2013, with total expenditures totaling $4.7 billion in 2013, up from $4 billion 2010 but down from $6 billion in 2011 (see Figure V-11).

Figure V-11: Aggregate Capital Expenditures
2010-2013



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

While 130 of the 160 respondents reported having capital expenditures in 2013, just 35 reported REE-related capital expenditures, with a total of $505 million. Most of these expenditures were attributable to a single respondent, which accounted for more than 50 percent of all REE-related

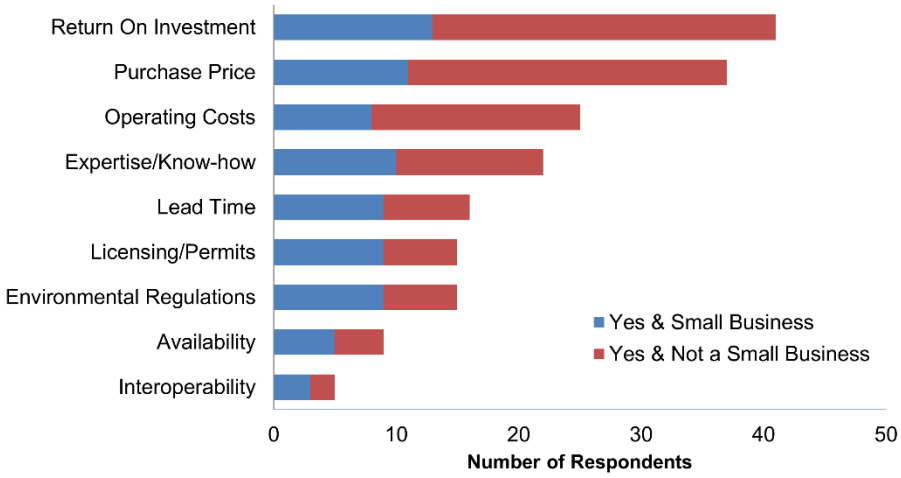
capital expenditures. Thirteen respondents reported that their REE-related capital expenditures exceeded one million dollars in 2013.

Respondents were asked if their organization's capital expenditures had been adversely impacted by reductions in USG defense spending in the past (2010 to 2013), future (2014 to 2018), or both. Most respondents capital expenditures were not affected by reduced USG defense spending, though 32 (20 percent) indicated that it had been or would be, with 26 of these indicating it was an ongoing issue. One large respondent with REE-related capital expenditures commented, "Sequestration has impacted the timing of the key DOD programs we currently support and plan to support in the future". Another respondent wrote, "Future demand is uncertain and we are reluctant to release capital until the market is more clear".

Respondents were asked to describe any obstacles to their future procurement of new machinery, technology, and/or facilities necessary for expanding their REE-related business lines. 'Return on Investment' was the most-often selected obstacle for both small businesses and larger businesses, with 41 respondents (26 percent) selecting it (see Figure V-12). When discussing this category, one respondent mentioned, "Current Chinese pricing competition makes it very difficult to make a sufficient ROI on capital purchases of new equipment, facilities or technology. Operating costs must be held at current levels or even reduced to remain competitive."

The most significant barriers to entry specific to small businesses were 'Lead Time', 'Licensing/Permits', and 'Environmental Regulations.' In each of these areas the number of small businesses selecting the problem outnumbered non-small businesses, despite small businesses representing under half of the overall respondents.

Figure V-12: Obstacles to Future Procurement of Capital Goods Necessary for Expansion



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

VI. INNOVATION: SUBSTITUTION, RECYCLING, AND R&D

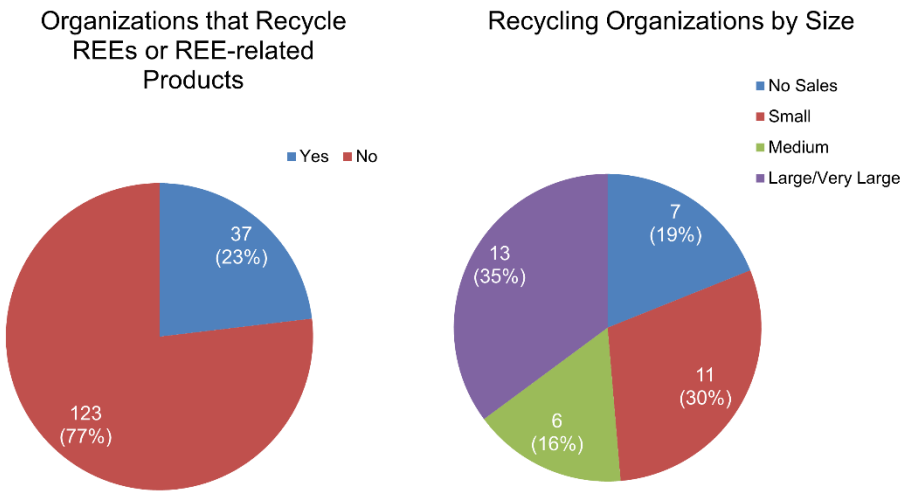
With supply chain constraints and price volatility among the leading challenges to organizations working with REEs and REE-related products, recycling and substitution may offer opportunities to help stabilize REE supply. Recycling is defined as the safe removal of REE and REE-related inputs from finished goods for reuse in new products. Substitution is defined as the act of replacing a REE or REE-related input with another input.

Respondents detailed the strategies they employed with respect to recycling and substitution as well as constraints limiting their organization's ability to implement REE recycling or substitution programs. BIS also captured data covering larger trends in Research & Development (R&D) among the respondents, with a particular focus on REE-related business lines and products.

Recycling

Respondents were asked whether they recycled REEs or REE-related inputs as well as whether they used recycled REEs or REE-related products. Thirty-seven respondents (23 percent) recycled REEs or REE-related products, and 31 respondents (20 percent) use recycled REEs or REE-related products. The organizations that responded that they recycle REEs were primarily Commercial organizations (33 respondents, 89 percent), with three U.S. Government Organizations and one University also positively responding. All sizes of organizations recycle REEs or REE-related products. Of the 37 respondents who recycle, 13 organizations (35 percent) were large or very large, 11 organizations (30 percent) were small, seven organizations (19 percent) had no sales, and six organizations (16 percent) were medium-sized (see Figure VI-1).

Figure VI-1: Recycling REEs or REE-related Products



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

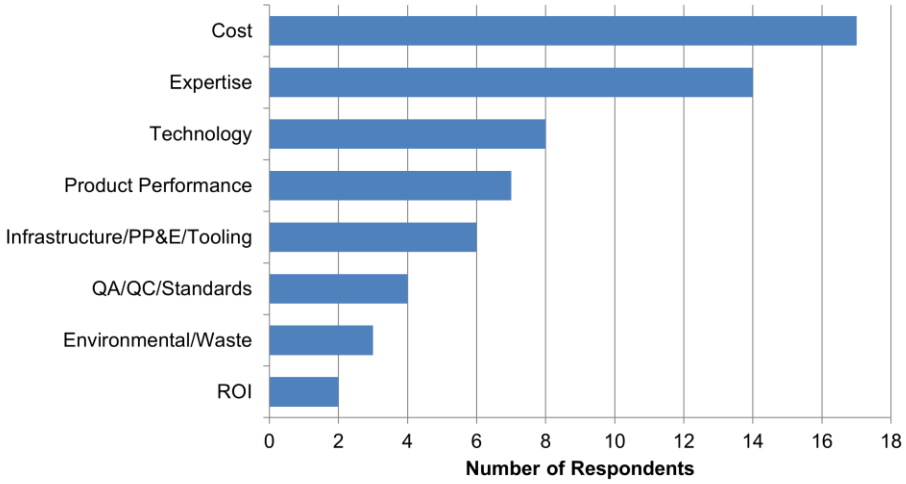
Six organizations listed recycling as their primary line of business, and another 14 listed it as an additional business line. For the organizations that conducted REE recycling as an additional line of business, the most often cited reason for doing so was to 'reduce unit or acquisition costs' and to 'increase profit margins.' These and similar comments were offered by REE or REE-related product manufacturers of all sizes.

Respondents were asked to identify the primary prohibiting factors to recycling. 'Cost' and 'Expertise' were cited as the most common constraints, with 17 and 14 respondents citing those constraints, respectively (see Figure VI-2). 'Technology' and 'Product Performance' were the third and fourth most cited constraints, with eight and seven respondents.

While discussing the cost constraints of recycling low volumes of REEs, one respondent commented, "The cost of recycling, and the technology and resources required to recycle REEs,

will not be economically attractive given the availability of primary REE on site". Other organizations commented that recycling was limited to certain elements or compounds, and they did not have the expertise to recycle their REEs and REE-related products such as polyphase crystal or rare earth magnets. Another factor not listed was the limited volume of products; several respondents commented that the quantity of REEs or REE-related products used on an annual basis was too low to make recycling 'worthwhile.'

Figure VI-2: Constraints to Recycling: Prohibiting Factors



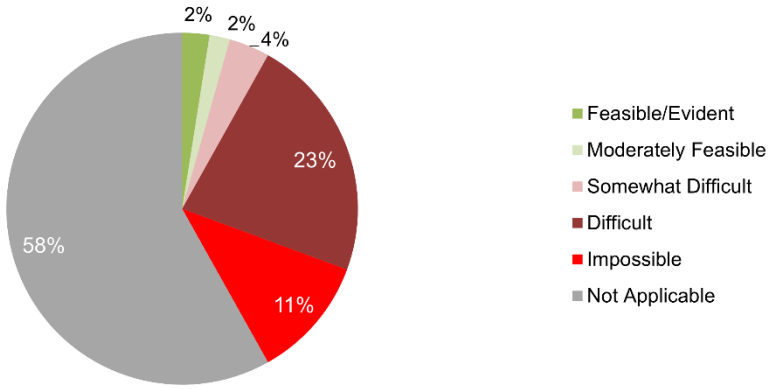
Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

For those respondents who did not currently recycle REEs or REE-related products, they were further asked to assess the company's perceptions of the feasibility of beginning REE recycling programs. Of the 67 respondents to the question, four respondents believed implementing a recycling program was feasible (See Figure VI-3). Thirty-six respondents (23 percent) claimed beginning a recycling program would be difficult, and 18 respondents (11 percent) argued it would be impossible. The respondents who ranked REE recycling programs as 'Somewhat

Difficult,' 'Difficult,' or 'Impossible' were commercial organizations of all sizes (small, medium, large, and very large).

Figure VI-3: Feasibility of Recycling REEs or REE-Related Products

Company perceptions of the feasibility of beginning recycling programs



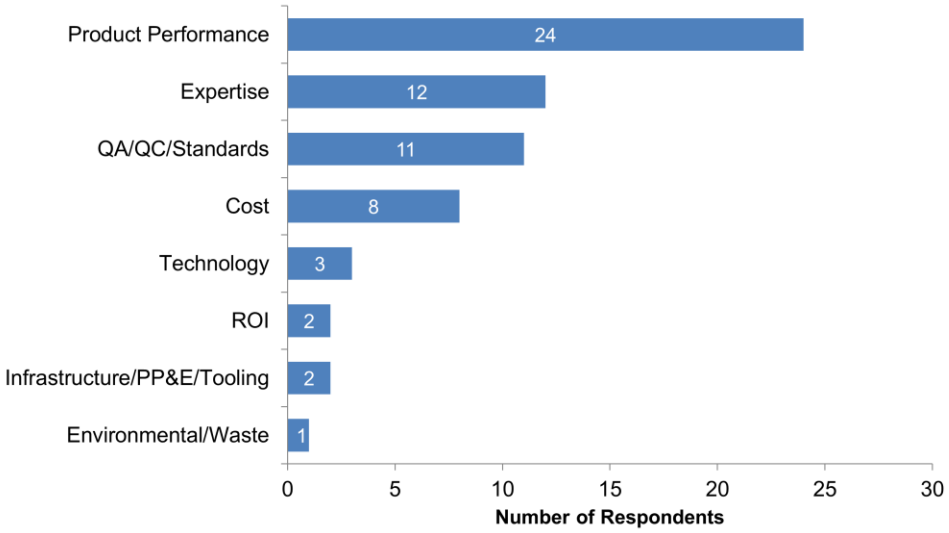
Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Separately from REE recycling capability, respondents were asked if their organizations used recycled REEs or REE-related products. Seventy-nine percent of respondents indicated that they did not use recycled REEs or REE-related products. Of those 136 organizations that did not use recycled REEs, 132 (98 percent) had no plans to use recycled REE's in the next five years, from 2014-2018.

The organizations that did not use or plan to use recycled REEs or REE products were asked to identify the primary constraints to doing so (see Figure VI-4). 'Product Performance' was the most frequently cited constraint to using recycled REEs, with 24 respondents citing it as their primary constraint. 'Expertise,' 'Qualification Standards,' and 'Cost' were also listed by 12, 11,

and eight respondents, respectively. When asked to elaborate, one respondent commented that "Product performance is not acceptable." Another respondent commented, "As long as supply remains available, requalifying recycled REE would not be cost effective," while a third respondent believed that "recycling costs are higher than mining costs."

Figure VI-4: Primary Constraints to the Use of Recycled REEs



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

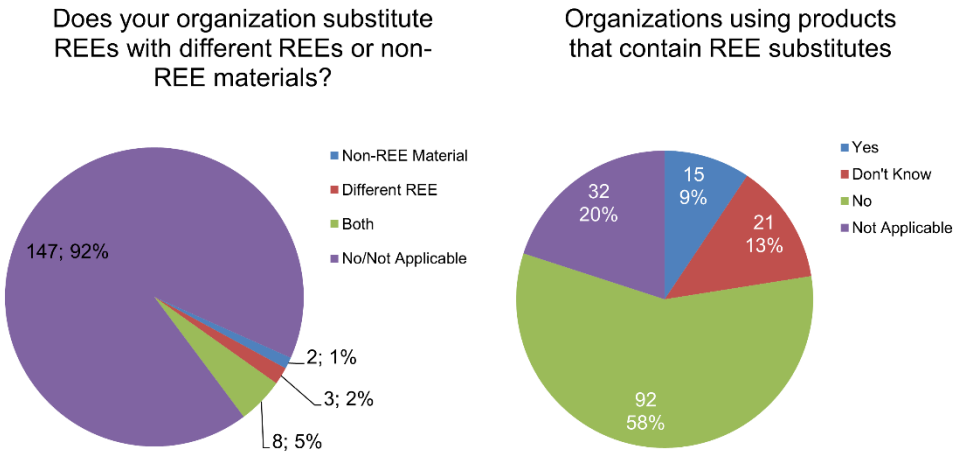
Substitution

Respondents were asked if their organization substituted REEs with different REEs or non-REE materials. Only 13 respondents (eight percent) substituted REEs with different REEs, non-REE materials, or both (see Figure VI-5).

However, a higher percentage of organizations responded that they used products containing REE substitutes. Fifteen respondents (nine percent) use products that contain REE substitutes. Of those fifteen organizations using products containing REE substitutes, 10 were commercial

organizations primarily working in manufacturing, distribution, or end use/applications. The five remaining organizations using REE substitutes were U.S. Government organizations or Universities conducting R&D.

Figure VI-5: Substitution of REEs



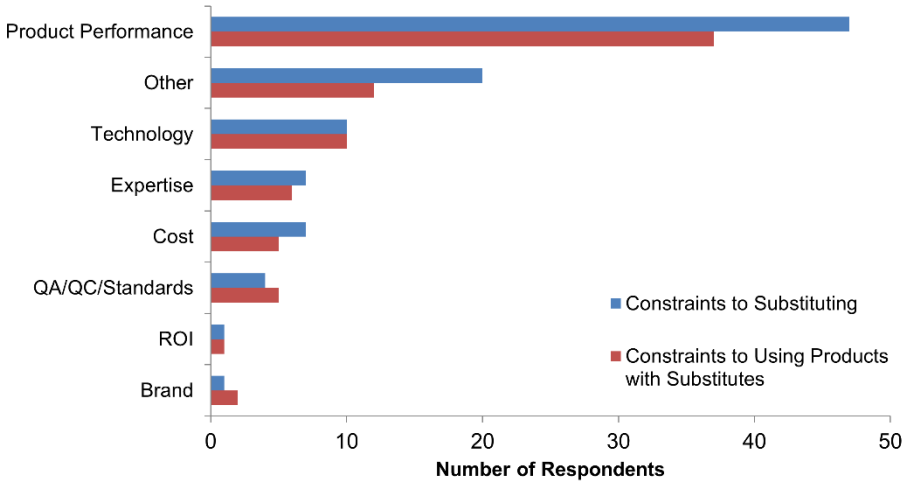
Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

The respondents who did not substitute REEs or use products with REE substitutes were asked to identify the primary constraint to substituting REEs with different REEs or non-REE products. The most commonly cited constraints were similar for both areas, with 'Product Performance' being the most noted constraint (see Figure VI-6). Respondents were vocal about their inability to substitute REEs due to their "critical performance" attributes. For example, one respondent commented, "Neodymium is the strongest natural magnetic material, there is no substitute available with the strength or [we would] already be using it in our magnets." On using products with substitutes, another respondent wrote, "Ceramic magnets are much weaker than REE magnets – end product performance would be significantly different." Other elements

specifically cited for their unique performance attributes were Cerium, Erbium, Yttrium, and Ytterbium.

The second and third most cited constraints to REE substitution were 'Other' (20 respondents), and 'Technology' (10 respondents). 'Other' categories focused on the availability of REE substitutes for specific elements such as Cerium or Lanthanium. Additional respondents focused on the challenges associated with requalifying REE substitutes: "Existing products are qualified to military, space and medical regulatory agencies such as [the] FDA. Material changes are not allowed – would require requalification of the product line." For 'Technology', the prevailing explanation was that the technology did not exist to substitute for the REEs in question.

Figure VI-6: Constraints to Substituting REEs with Different REEs or Non-REE Materials

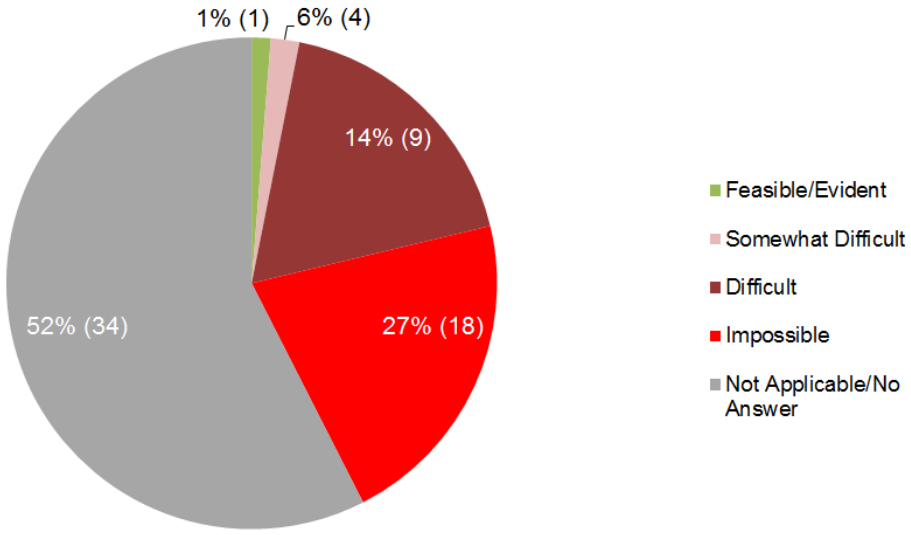


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Respondents who did not use products containing REE substitutes were also asked to indicate the feasibility of using REE substitutes or products containing REE substitutes. Eighteen

respondents (27 percent) indicated that it was impossible to use substitutes, and nine respondents (14 percent) indicated that it would be difficult. Five respondents (seven percent) indicated that using REE substitutes was feasible or somewhat difficult. (see Figure VI-7).

Figure VI-7: Feasibility of Using REE Substitutes or Products Containing Substitutes



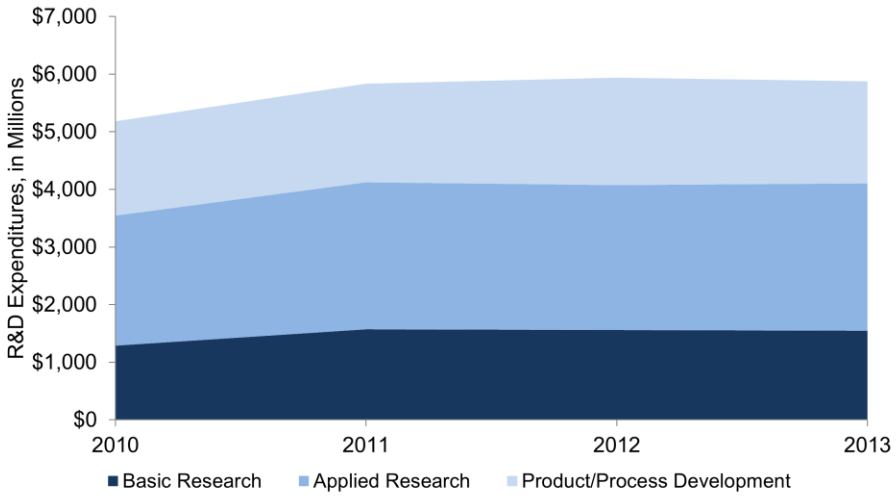
Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Research & Development

Overall research and development (R&D) expenditures were relatively stable between 2010 and 2013, peaking at $6 billion in 2012 (see Figure VI-8). Respondents also reported type of R&D undertaken, which was also relatively stable and evenly spread. Forty-two percent of R&D funding was devoted to Applied Research in 2013, up from 41 percent in 2010. The portion of

funding devoted to Basic Research rose slightly from 30 to 31 percent, while Product/Process Development decreased slightly from 28 to 27 percent of total R&D funding.

Figure VI-8: Aggregate R&D Expenditures
2010-2013



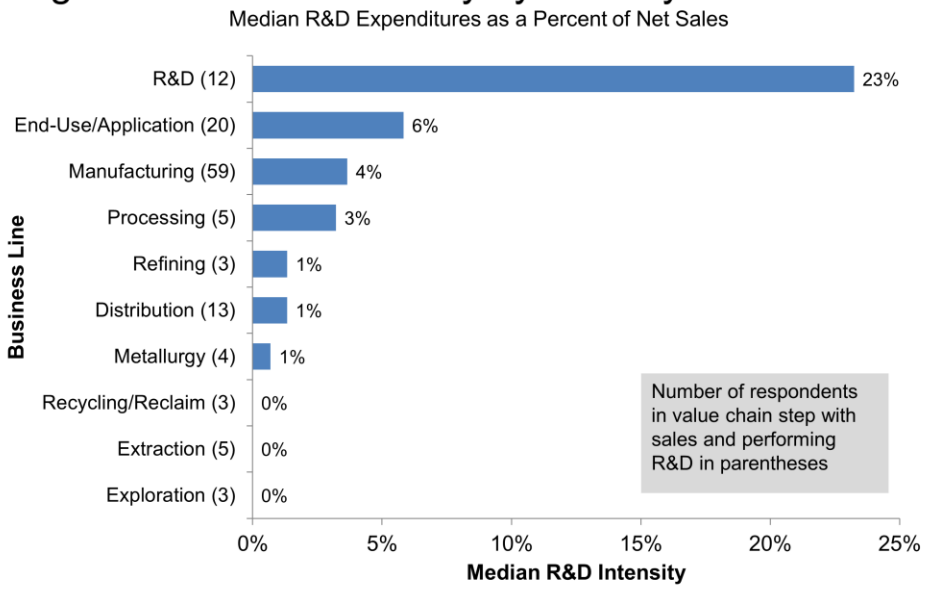
Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

At an individual respondent level, most R&D was not directed toward REE-specific areas. While 111 respondents had R&D expenditures in 2013, just 61 reported R&D expenditures for their REE-related business lines, and these expenditures totaled $254 million—approxiately four percent of the total R&D expenditures.

Expenditures were highly concentrated, with three large research-oriented organizations accounting for over half of the total R&D expenditures from 2010 to 2013. Two of these organizations reported no REE-specific R&D expenditures, while the third spent roughly 10 percent of their overall R&D budget on REE-related R&D.

In order to better understand what types of organizations were most focused on R&D, BIS calculated the median expenditure as a percent of net sales for each business line in the value chain step. This calculation created an indicator of R&D expenditure intensity, which varied greatly across the business lines. Those respondents identifying R&D specifically as one of their business lines spent a much higher percentage of their sales on R&D than did other organizations working in other steps of the value chain, with the median R&D intensity for the R&D business line calculated as 23 percent (see Figure VI-9). The R&D expenditure intensity dropped significantly from there. The second, third, and fourth, business lines – End-Use/Application, Manufacturing, and Processing – represented R&D expenditures of six, four, and three percent of their net sales.

Figure VI-9: R&D Intensity by Primary Business Line



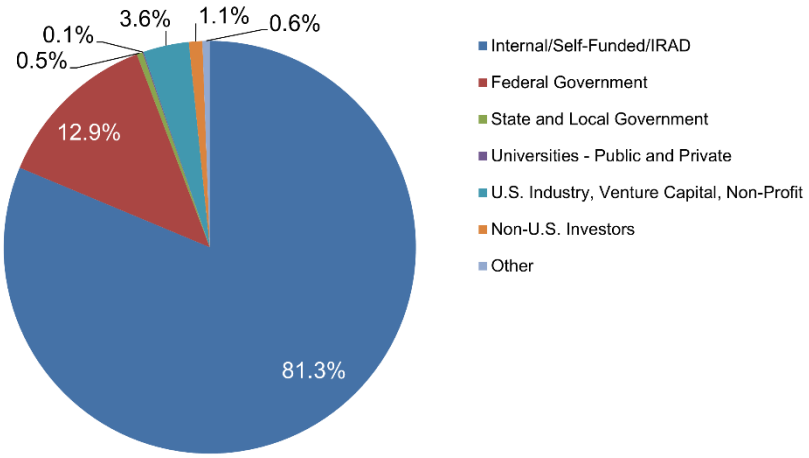
Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

The source of R&D funding was predominantly internal. In 2013, 81.3 percent of respondents' R&D funding sources were reported as internal. Thirteen percent of R&D funding came from

the U.S. Government, while 3.6 percent came from U.S. industry (see Figure VI-10). Thirty-five organizations received federal R&D funding, and 18 of these had REE-related expenditures. Unsurprisingly, these respondents tended to have more involvement with the USG across their business. The 18 respondents with REE-related R&D expenditures and federal R&D funding listed 97 USG programs they supported (over one-quarter of the total), and 43 percent of all reported REE-related sales to the USG.

Figure VI-10: R&D Funding Sources

Average source of R&D funding, 2013

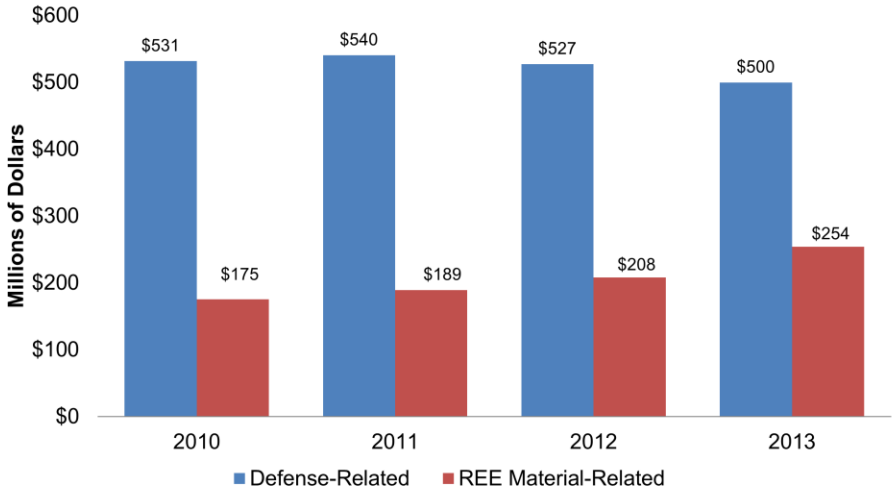


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Outside of these USG-focused respondents, relatively little R&D as a whole was focused on defense uses or REE-related business lines. Total defense-related R&D expenditures were roughly $500 million annually – under ten percent of all R&D expenditures. REE-related R&D was performed at a lower rate, though it rose from $175 million in 2010 to $254 million in 2013 (see Figure IV-11).

Figure VI-11: Estimated R&D Expenditures Relating to Defense-Related Business Lines

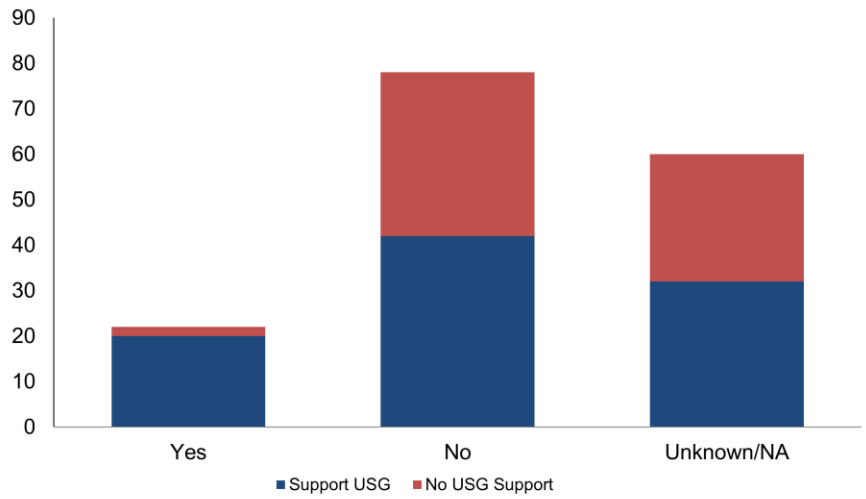
2010-2013



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

BIS asked respondents if their defense-related R&D shaped the development of their commercial lines (see Figure VI-12). Most responded 'No' or 'Not Applicable', but 22 respondents (14 percent) indicated that their defense-related R&D did shape their commercial lines. Nearly all of these 22 respondents supported a USG agency, while other categories were virtually evenly split. Those respondents indicating that their defense-related R&D shaped their commercial lines represented several business lines (Manufacturers and End-Use/Application predominantly) and worked on several product lines, such as optical thin films, fiber laser technologies, and next-generation magnets.

Figure VI-12: Does defense-related R&D shape the development of your commercial product line?



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

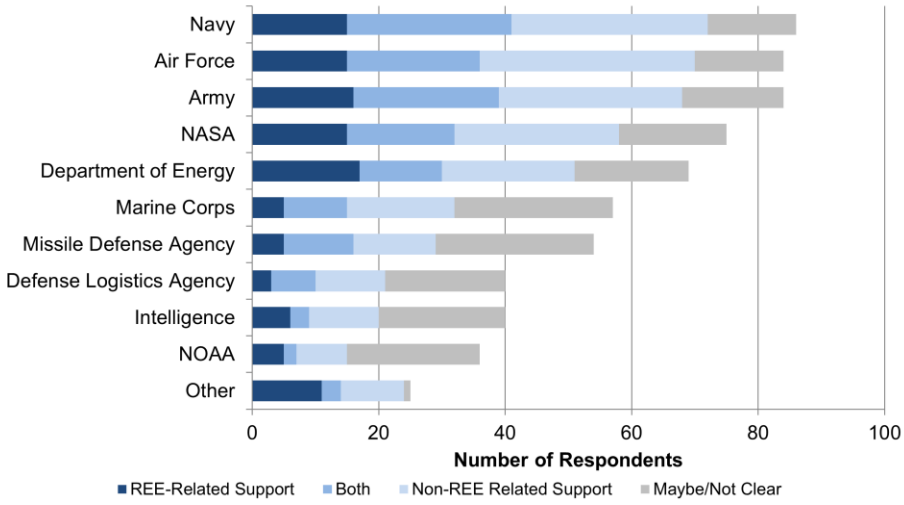
Respondents were also asked if their organizations performed any R&D activities related to REE recycling or substitution. A total of 20 respondents indicated they performed REE recycling or substitution R&D, with five doing both, eight performing recycling R&D only, and seven performing substitution R&D only. Most of these organizations were devoting little to REE recycling or substitution R&D, with 12 reporting five percent of less of their R&D expenditures focused on this area. However, five respondents did note that over one-third of their R&D expenditures were targeted at REE recycling or substitution. One of these respondents indicated that their R&D was focused on the "development of cost-effective processes to separate rare earth from electronic and industrial sources", while another noted the recovery of REEs from fluorescent lamps as an area of focus.

VII. Support for U.S. Government Agencies

The U.S. Government (USG) is an important source of business for many respondent organizations, particularly for defense applications. Although the period from 2010 to 2013 was one of diminishing overall sales to the USG, these transactions still accounted for nearly one-third of all reported sales in 2013. One hundred two of the 160 respondents (64 percent) reported that they provided support to at least one USG agency from 2010 to 2013.

The greatest number of respondents supported the Department of Defense (DOD) Service Branches, the Department of Energy, Missile Defense Agency, and the National Aeronautics and Space Administration (NASA) (see Figure VII-1). 'Other' agencies included the Defense Advanced Research Projects Agency (DARPA), the Environmental Protection Agency (EPA), the National Institutes of Health (NIH), and the National Science Foundation (NSF).

Figure VII-1: Support for USG Agencies

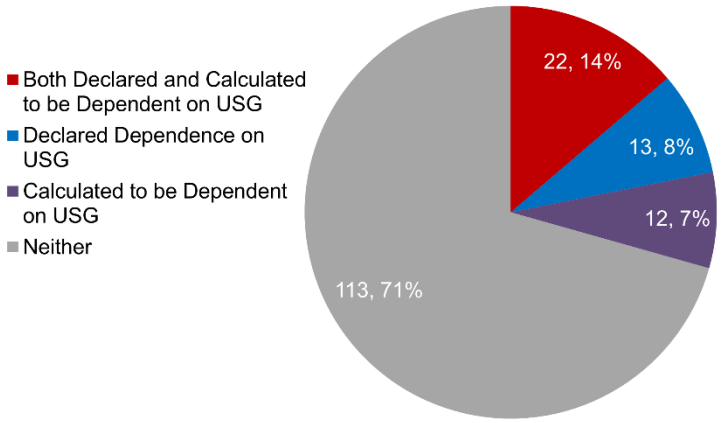


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Respondents were asked if their organizations considered themselves dependent on USG programs for continued viability. To more accurately portray potential dependence on the USG, BIS also added a calculated measure of dependence, using a threshold of at least 25 percent of sales to the USG. Twenty-two respondents (14 percent) were both self-declared and calculated by BIS to be dependent on the USG. Twelve additional respondents (eight percent) were calculated to be dependent on the USG, while thirteen respondents (eight percent) declared themselves dependent but were not determined by BIS to be so, providing a total of 47 respondents that were dependent on the USG (see Figure VII-2).

Figure VII-2: Dependence on USG for Viability

Calculated dependence based on at least 25% of sales to the USG



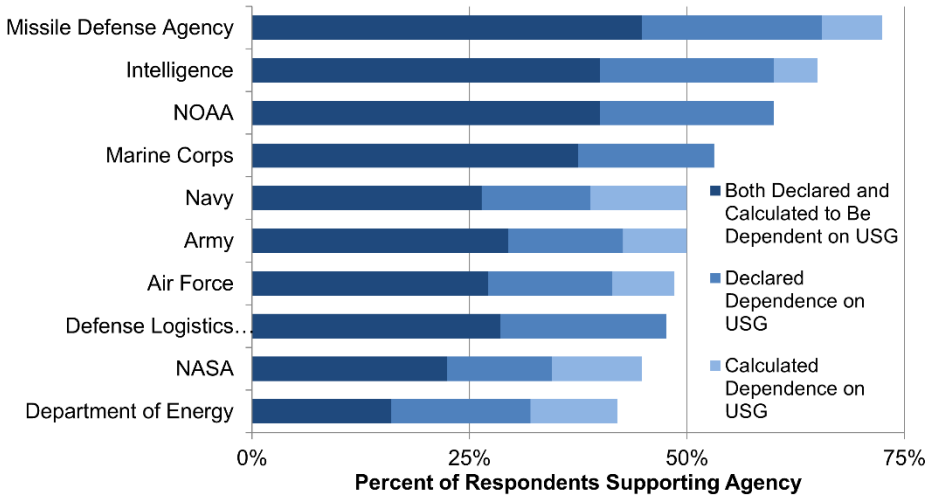
Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

The types of organizations dependent on the USG for continued viability (both self-determined and calculated by BIS) varied across size and business line. While most business lines were represented in these respondents, the lines with the greater proportions of USG dependent respondents were Substitution, R&D, and Recycling, with a combined 46 percent of respondents

identified as potentially dependent on the USG for continued viability. Respondents from these categories offered further explanation for their dependence on USG programs. For example, one organization working in R&D commented, "Federal grants and contracts are critical for research funding." Another respondent noted their efforts to diversify writing, "In the early days, 100 percent of our business was based on U.S. Government programs. We are working to reduce dependency on U.S. Government programs but those programs still represent roughly 60 percent of our business activity."

A significant number of the 102 respondents supporting USG agencies were dependent on the USG for their continued viability. Over half of the respondents supporting four USG agencies were dependent on the USG, including nearly three-quarters of those supporting the Missile Defense Agency (see Figure VII-3). USG dependent respondents also tended to work with more USG agencies than other respondents, supporting an average of nearly half of the 10 USG agencies listed. Respondents not dependent on the USG supported, on average, under two USG agencies.

Figure VII-3: Percent of Respondents Supporting Each Agency Dependent on USG

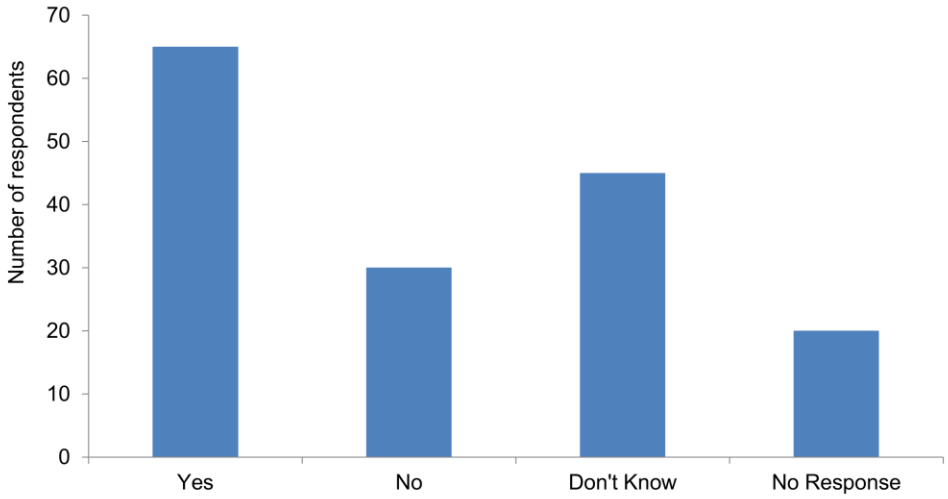


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

For those respondents supporting USG programs, BIS asked if their organization's DOD-specific REE-related business lines were integrated with or separate from their commercial operations Sixty-one respondents had REE-related business lines that were integrated between their DOD and commercial businesses. Fifteen respondents indicated that their REE-related business lines were separate. Respondents dependent on the USG were more likely to have separate business lines, reporting separate lines at nearly twice the rate of those not dependent on the USG.

BIS also asked respondents if their organization could readily convert government business lines to commercial ones in the case of a sudden or steep decline in USG demand for REE-related products and/or services (see Figure VII-4). Sixty-five respondents (41 percent) indicated that their REE-related business lines were convertible from USG to commercial. Thirty respondents (19 percent) indicated that they could not convert their REE-related business lines from USG to commercial.

Figure VII-4: REE-related Products/Services Convertible from USG to Commercial

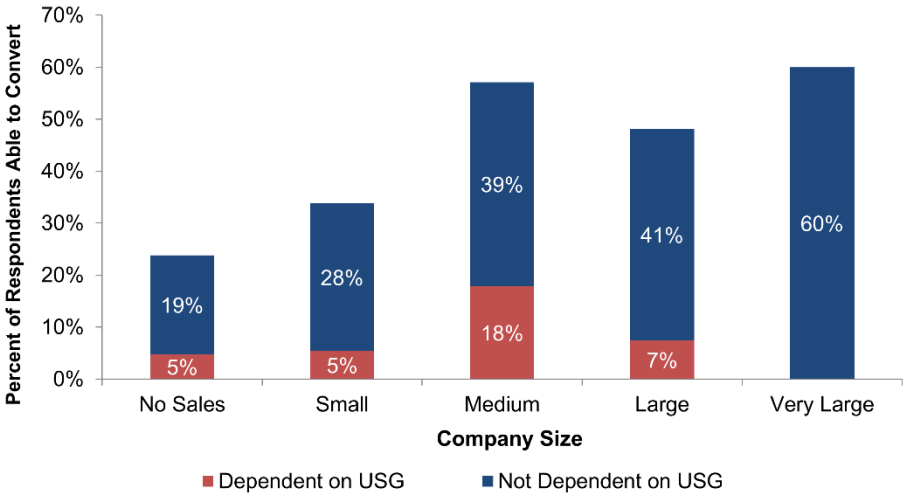


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

The ability of respondents to convert REE-related business lines in the event of a steep decline in USG demand was fairly consistent across respondent size categories (see Figure VII-5). Size categories were determined by sales. Very large companies were the most convertible. Six of the 10 very large companies (60 percent) were able to convert their USG business lines to commercial in the event of a steep decline in USG demand. Small companies were less versatile but also more abundant. Twenty-five of 74 small companies (33 percent) were able to convert their USG business lines to commercial business lines in the event of steep decline in USG demand. Fifty-seven percent of medium-sized companies and forty-eight percent of large companies could switch USG business lines to commercial business lines.

Figure VII-5: Convertibility of USG Business Lines to Commercial by Organization Size

Ability to convert REE business lines in event of steep decline in USG demand

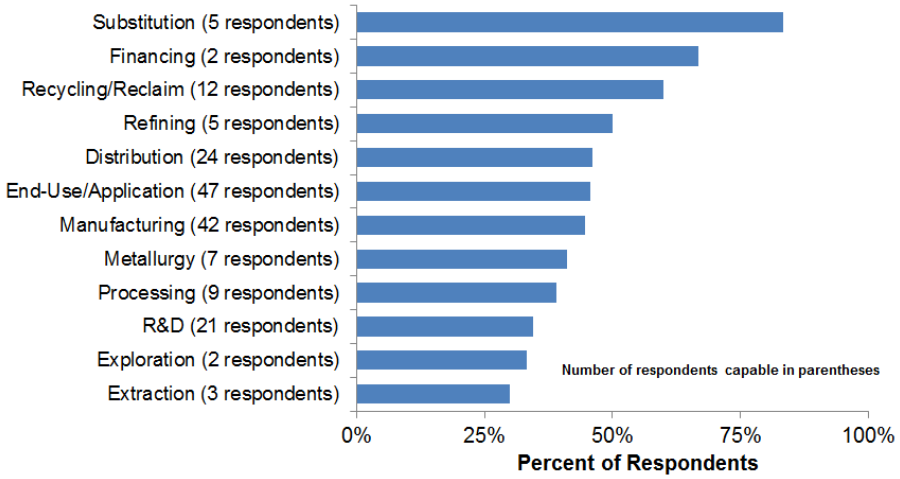


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

In general respondents closer to the end of the value chain were more likely to be able to readily convert government business lines to commercial ones (see Figure VII-6). Respondents focused on Substitution, Recycling, Distribution, and End-Uses were all more likely to be able to convert USG business lines to commercial than areas like Extraction, Exploration, R&D, and Processing, perhaps reflecting the more capital-intensive nature of the latter business lines.

Figure VII-6: Convertibility of USG Business Lines to Commercial

Ability to convert REE business lines in event of steep decline in USG demand



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Respondents were asked to indicate how vulnerable their REE-related business lines were in response to variability in several sources of demand – USG defense, USG non-defense, and Commercial. Across the board, respondents' REE-related business lines showed more vulnerability to demand fluctuations than non-REE lines (see Figure VII-7). Of these, commercial REE and non-REE-related business lines showed the highest vulnerability to sudden shifts in demand. Seventy-six respondents (48 percent) indicated that their REE-related business lines were vulnerable to variability in commercial demand. Fifty-seven respondents (36 percent) indicated that their non-REE-related business lines were vulnerable to variability in commercial demand.

Figure VII-7: Demand Dependence

Vulnerability to Variability in Demand

Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

VIII: TRADE

The REE and REE-related products marketplace is global, with many REEs originally mined abroad—particularly in China—and many products containing REEs manufactured in the U.S. and sold around the world. In order to understand the respondents' activities in the global REE marketplace, BIS asked a series of questions about imports and exports of REEs, with a special focus on the DENTY elements. Respondents were asked to detail their importing and exporting activities of REE-related ore, compounds, and metals in terms of quantity, value, material product, and countries of trading partners.

Respondents were also asked to identify trends in trading REE products and anticipated challenges in doing so in the future. BIS also asked a series of hypothetical questions on potential changes in the production and supply of REEs in order to better understand the respondents' outlooks on their exposure to changes in the way REEs are supplied, both domestically and internationally.

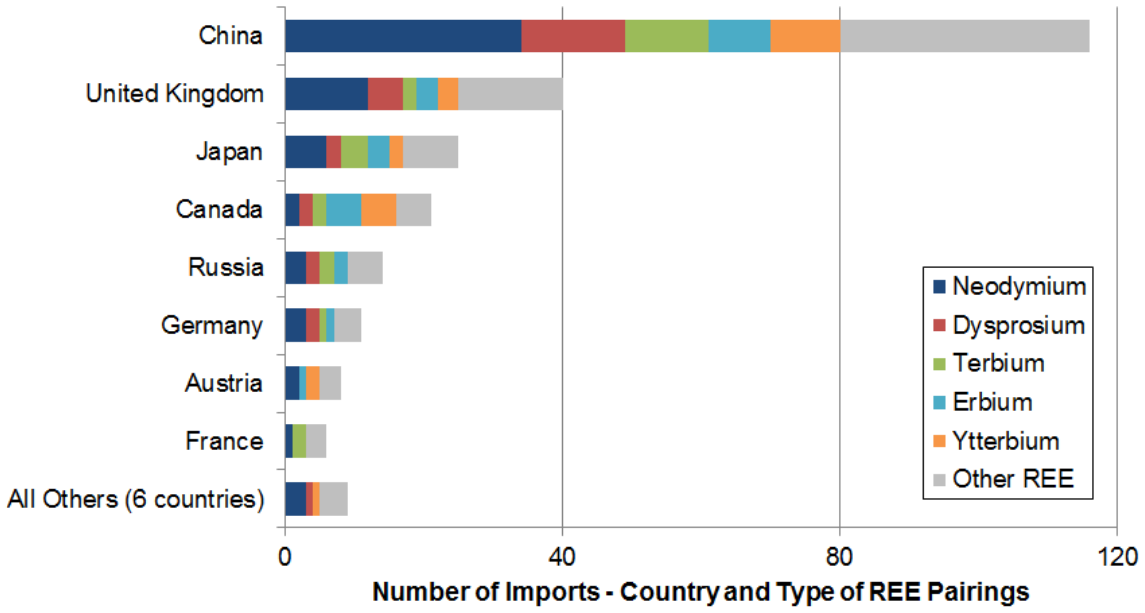
Imports

Sixty-six respondents indicated they imported REE-related ore, mixed compound, inorganic purified compound, organic purified compound, mixed metal, and/or purified metal between 2010 and 2013. Most importing respondents (46) imported from a single country, with China accounting for 28 (61 percent) of these single country importers. All but five of the remaining importers imported from two countries, and only two respondents with multiple countries of import did not import from China.

Respondents identified a total of 14 countries from which they imported these REE-related items, where the country of origin and the type of REE imported equaled to a total of a combination of 250 country and REE pairings (see Figure VIII-1). Among the DENTY REEs, Neodymium was the most common import, listed 66 times from 11 countries. Erbium imports were notable as the element least concentrated in China; while nine respondents imported Erbium from China, five imported it from Canada and three from Japan and the U.K. For every other REE, China accounted for more than twice as many import identifications as the next closest country.

Figure VIII-1: REEs Imported by Country

Respondents Importing Rare Earth Elements, 2010-2013

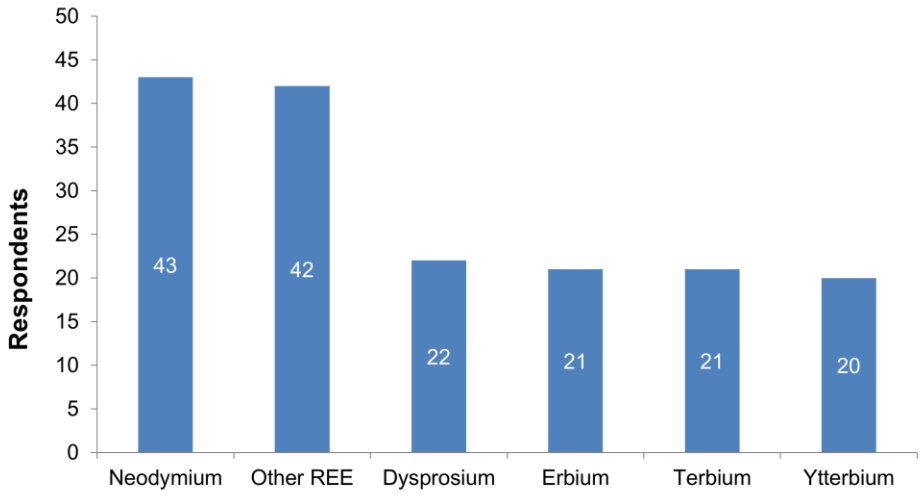


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Neodymium and 'Other REEs' were the most frequently identified REEs imported (see Figure VIII-2). Forty-three respondents (65 percent) reported importing Neodymium and 42 respondents (64 percent) reported importing 'Other REE'. The remaining DENTY elements – Dysprosium, Erbium, Terbium, and Ytterbium – were imported by at least 20 respondents (30 percent). One third of importing respondents imported just one REE, with most importing either Other REEs (9 respondents) or Neodymium (7 respondents). Just one or two respondents for each DENTY element reported importing only that single REE.

Figure VIII-2: Rare Earth Element Imports by REE

Number of Respondents by DENTY and Other REEs



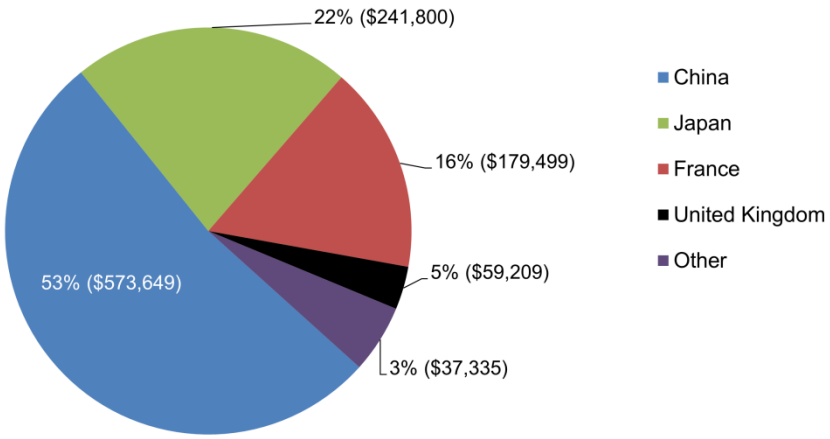
Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Respondents reported a total of $1.1 billion worth of imports of REE-related ore, compounds, and metals from 2010 to 2013. The top three importers accounted for nearly $995 million of these imports (91 percent), and the top five accounted for 96 percent of imports (see Figure VIII-3). All of these major importers brought in multiple REE types, including non-DENTY REEs. While China accounted for 91 percent of the volume by weight of REEs imported by

respondents, it made up 53 percent ($574 million) of the value of imports. Japan accounted for 22 percent of the value of REE imports with $242 million. France and the United Kingdom were the third and fourth highest in import values, at 16 percent ($179 million) and 5 percent (59 million) of the total, respectively. 'Other' nations represented the remaining three percent ($37 million).

Figure VIII-3: Total Value of Rare Earth Elements Imported from Each Foreign Source

2010-2013, Reported in the thousands of dollars



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Respondents reported which REE they imported from each of the 14 countries. Four countries – Canada, China, Japan, and the United Kingdom – supplied all focus elements (see Figure VIII-4). Another six countries provided only one of the DENTY elements, each to one respondent. In total, respondents listed at least six countries of import for each element (five countries for Ytterbium), with 11 different countries of import identified for Neodymium.

Figure VIII-4: Rare Earth Element by Import Source

	Dysprosium	Erbium	Neodymium	Terbium	Ytterbium	Other
Austria		1	2		2	3
Canada	2	5	2	2	5	5
China	15	9	34	12	10	36
Estonia			1			1
France			1	2		3
Germany	2	1	3	1		4
Japan	2	3	6	4	2	8
Laos			1			1
Netherlands			1			
Russia	2	2	3	2		5
South Korea					1	1
Spain						1
Thailand	1					
United Kingdom	1					
TOTAL NUMBER OF COUNTRIES PROVIDING IMPORTS TO RESPONDENTS	7	6	10	6	5	11

Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

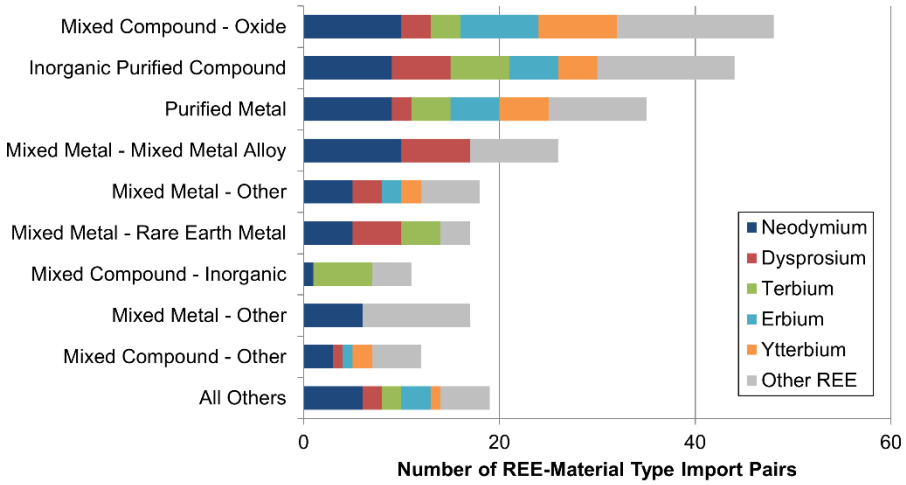
Respondents also reported the material type of each import from the subcategories of ore, mixed compound, mixed metal, purified compound, and purified metal.[8] By number of imports, 'Mixed Compound – Oxide' and 'Inorganic Purified Compound' were the most frequently identified, and included all REE types (see Figure VIII-5). Some material types were imported for more specific REE uses, such as 'Mixed Metal Alloys', which were imported only for

[8] Material Type Categories Provided: Ore (Bastnaesite, Monazite, Xenotime, Eudialyte, Ancylite, Allanite, Churchite, Limorite, Kaisonite, Fergusonite, Apatite, Other), Mixed Compound (Concentrate, Chloride, Nitrate, Inorganic Rare Earth Compounds, Organic Rare Earth Compounds, Fluoride, Hydroxide, Oxide, Sulfate, Rare Earth Garnet, Other), Mixed Metal (Mischmetal, Rare Earth Silicide, Rare Earth Metal, Mixed Metal Rare Earth Alloy, Didymium, Lanthanum Silicide, Cerium Silicide, Other), Inorganic Purified Compound, Organic Purified Compound, Purified Metal, Unknown, Not Applicable.

Neodymium and Dysprosium (of the DENTY), and 'Mixed Compound – Inorganic', which was used primarily for Terbium.

Figure VIII-5: REEs Imported by Material Type

Respondents Importing Rare Earth Elements Since 2010

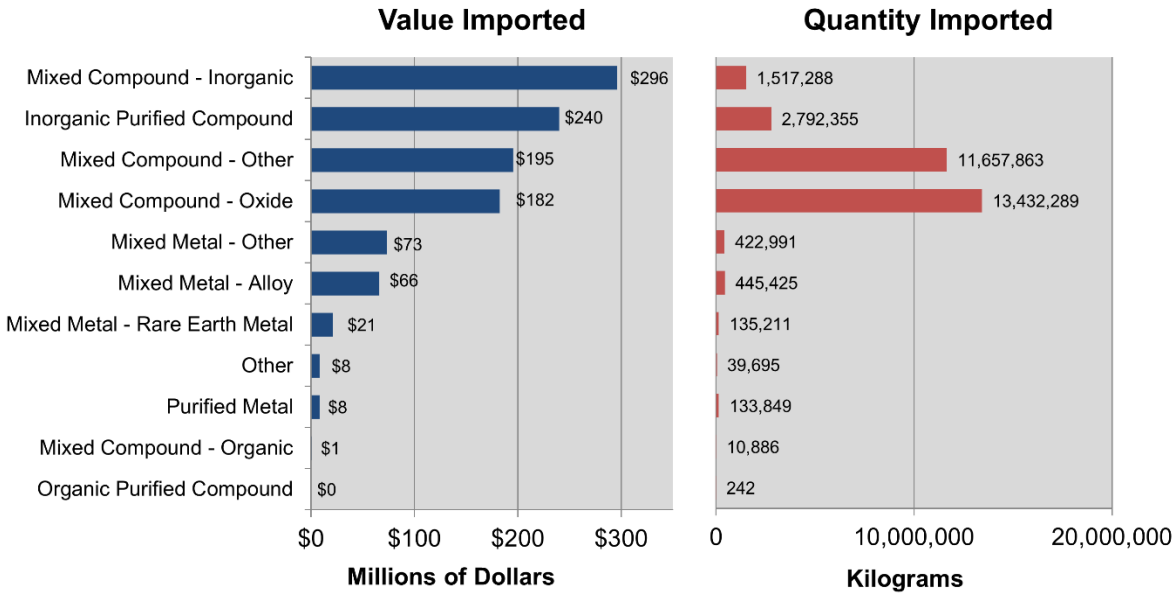


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Values and quantities of material types imported varied greatly (see Figure VIII-6). The greatest value of imported materials was Inorganic Mixed Compounds and Inorganic Purified Compounds, while other types of Mixed Compounds, particularly oxides, accounted for by far the greatest weight of material imported.

Figure VIII-6: Material Type Quantities Imported

Respondents Importing Rare Earth Elements Since 2010



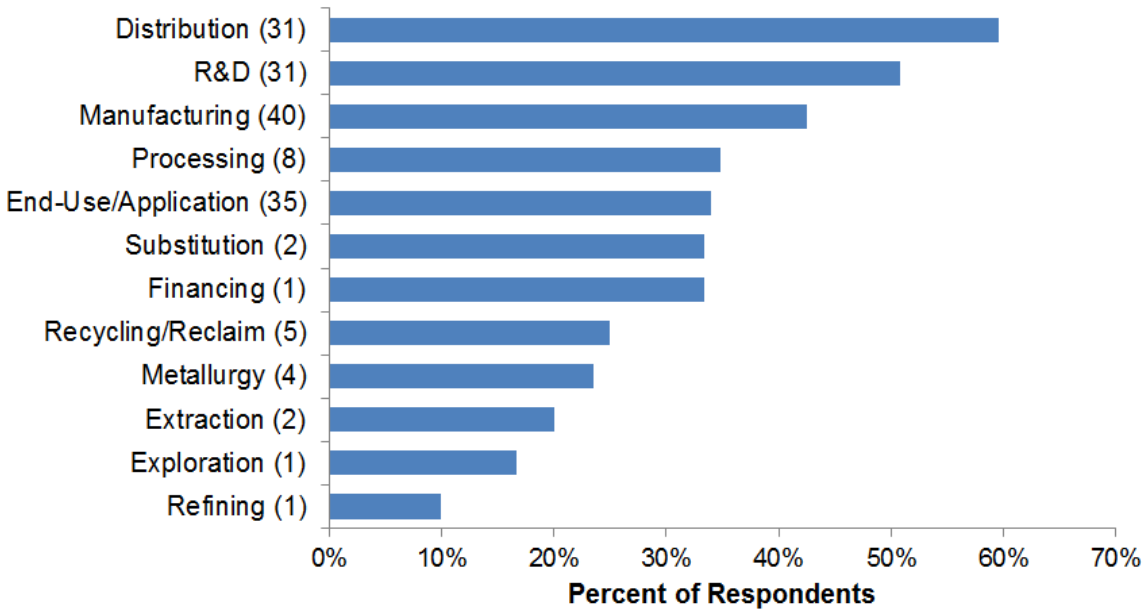
Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Respondents reporting REE imports were located at different steps in the supply chain network, as determined by their reported business lines. The 66 importing respondents represented all 12 value-step categories present in the full respondent sample.[9] However, not every respondent within any single value-step category imported REE ore, compound, or metal. Sixty percent of respondents working in Distribution imported REE, representing the highest level of import participation within any value-step category. Of those conducting R&D as their primary business line, 51 percent reported importing. Of Manufacturers, 43 percent reported importing. In contrast, less than 20 percent of participants in extraction, exploration, and refining reported

[9] These value steps were determined in Q1c.A of the assessment. BIS provided the list, with definitions that can be found in the glossary. Value Steps: Financing, Exploration, Extraction, Refining, Processing, Metallurgy, Manufacturing, Distribution, Recycling/Reclaim, Substitution, Research and Development, End Use/Application.

importing (see Figure VIII-7). This is not surprising, due to the nature of each of these business lines.

Figure VIII-7: Importers of REEs by Value Step Participation



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

BIS collected data not only on current REE imports, but also on expected import changes and expected challenges. Twenty-two respondents (13 percent of total respondents, 33 percent of importers) reported anticipating increasing their imports of REE-related material in the next five years. Of those, almost half (10 respondents) expected to experience challenges in doing so. Most of the challenges related to concerns about the availability of REEs, particularly in China.

In an effort to understand future trends in REE imports, BIS asked respondents to predict the impacts of a series of hypothetical scenarios about possible market situations. Respondents

recorded whether they believed each scenario would affect their ability to maintain their REE-related business lines, and whether that impact would be positive or negative, and in the short or long-term.

In the first hypothetical scenario, respondents were asked to report the anticipated impact of China eliminating or softening its export quota restrictions on REEs and REE-related products. Thirty-six percent of respondents anticipated a positive impact, while seven percent anticipated a negative impact. A respondent predicting a positive impact explained that the softening of export quota restrictions "levels the playing field between REE consumers in China and the rest of the world. Price and availability should improve." Thirty-one percent of respondents predicted that this elimination would have no impact, with one respondent claiming that quotas were irrelevant because "[China has] exceeded actual exports for years".

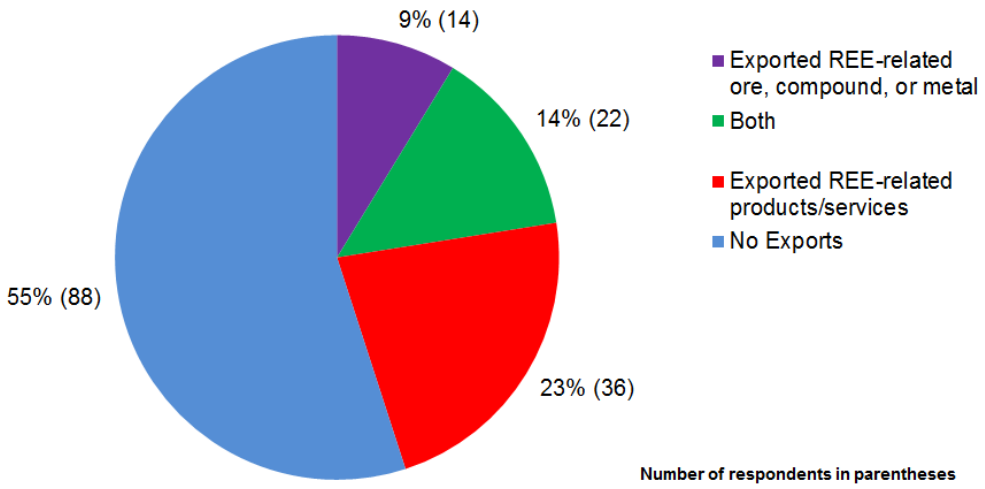
In the second hypothetical scenario, respondents were asked to report the anticipated impact of the imposition of more stringent production controls on China's REE-related products. Thirty percent of respondents anticipated no impact, and approximately the same proportion (29 percent) believed such controls would have a negative impact on their REE-related business lines. To explain this negative impact, one respondent claimed that, "Restrictions in supply of REEs to electronics industry will push component prices up." Another respondent commented, "The last production control in Chinese REE mining affected us for at least a year." One respondent expected a positive impact, predicting that such controls would "raise costs of Chinese production and level the playing field for domestic REE to compete as a non-China miner."

Exports

Of the 160 organizations surveyed, 36 respondents (23 percent) reported exporting REE-related ore, compound, or metal to 56 countries between 2010 and 2013. Another 36 respondents listed non-U.S. customers of their products or services, suggesting they exported intermediary or finished REE-containing products (see Figure VIII-8). Eighty-eight respondents (55 percent) reported that they did not export DENTY or other REE-related products during that period.

Figure VIII-8: Rare Earth Element Exports

Respondents Exporting Rare Earth Elements, 2010-2013

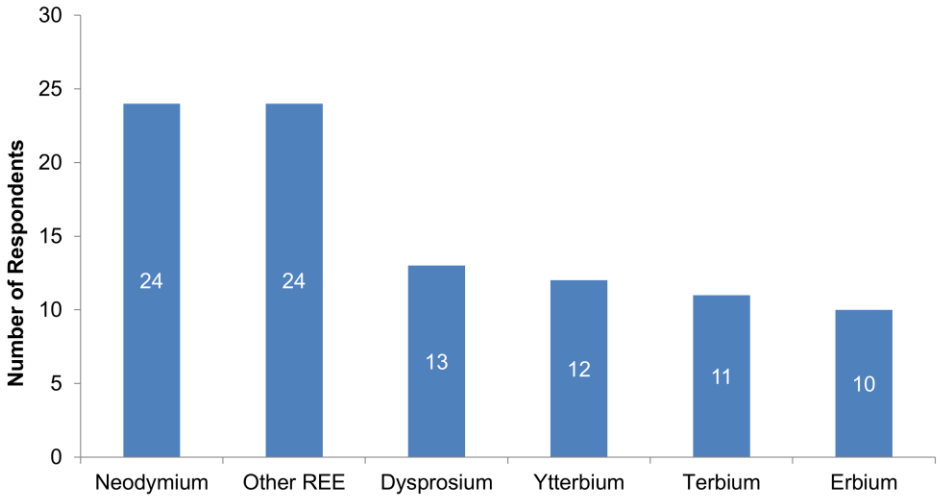


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

For respondents exporting REE-related ore, compound, or metal, BIS asked which of the focus DENTY elements were being exported between 2010 and 2013 (see Figure VIII-9). All five DENTY elements were exported, with Neodymium being exported by 24 respondents (67 percent) and Erbium being exported the least, with 10 respondents (28 percent) indicating that they exported it. 'Other REEs' were also exported by 24 respondents.

Figure VIII-9: Rare Earth Element Exports by REE

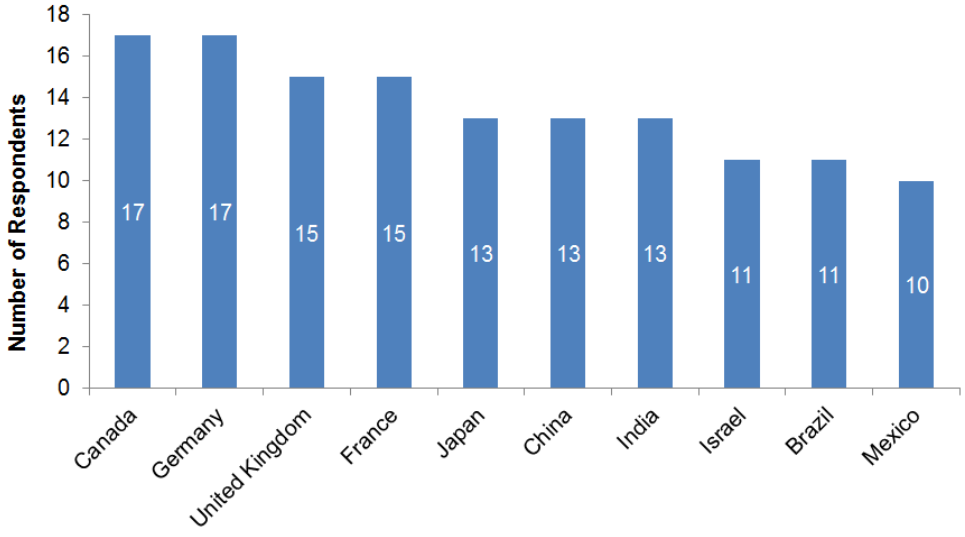
Number of Respondents by DENTY and Other REEs



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Of the 56 named countries to which respondents exported REE-related ores, compounds, or metals, Canada, Germany, the United Kingdom (U.K.), and France were most frequently identified (see Figure VIII-10). Seventeen respondents (42 percent) reported exporting to Canada and 17 respondents (42 percent) reported exporting to Germany, while fifteen respondents each (38 percent) reported exporting to the U.K. and France.

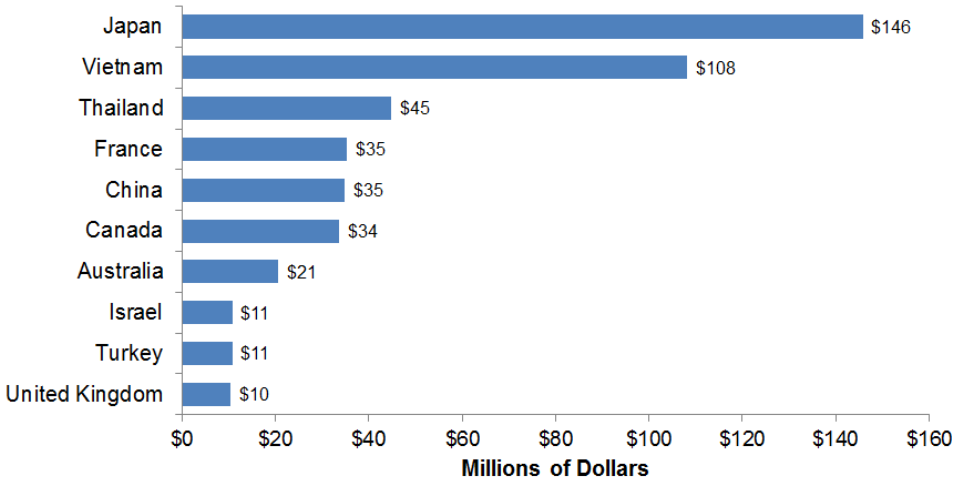
Figure VIII-10: Respondent Exports of Rare Earth Elements by Country



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

The total value of REE-related ore, compounds, and metals exported by the respondents between 2010 and 2013 was $525 million. While Japan was only the fourth highest importing nation by volume, it was by far the largest importing nation in terms of value. Respondents reported exporting $146 million of REE-related ore, compound, or metal to Japan during the time period (28 percent of the total value), followed by $108 million (21 percent) exported to Vietnam, and $45 million (nine percent) to Thailand (see Figure VIII-11).

Figure VIII-11: Value of Rare Earth Elements Exported by Country, 2010-2013

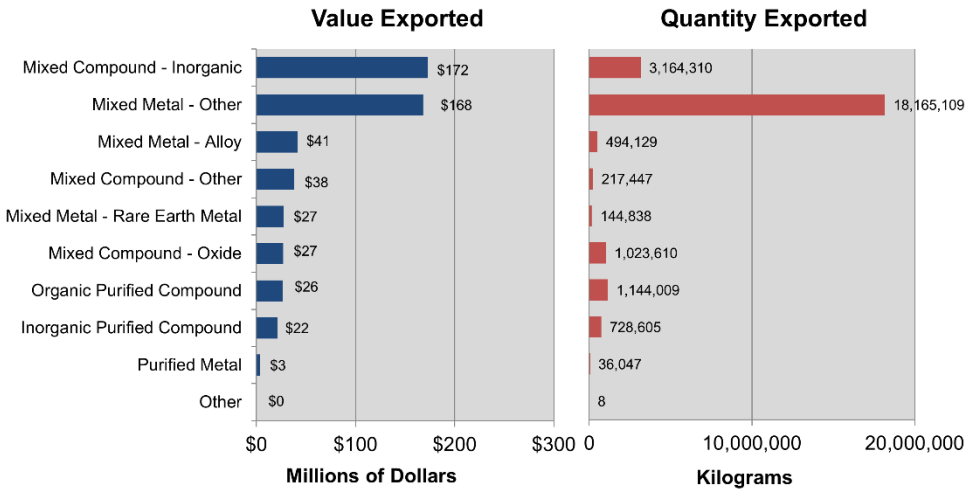


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

As with imports (see Figure VIII-6), 'Mixed Compound – Inorganic' was the leading material type by value, though by weight 'Mixed Metal – Other' was by far the most frequently exported material type (see Figure VIII-12). 'Inorganic Purified Compound', the second largest import by value, was far less commonly exported, as it was likely incorporated into products.

Figure VIII-12: Material Type Quantities Exported

Respondents Exporting Rare Earth Elements Since 2010

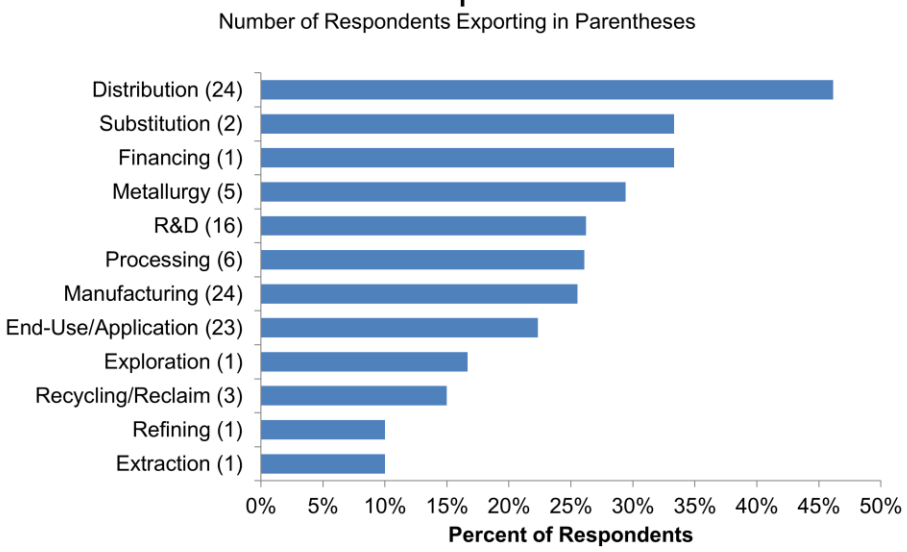


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Respondents reporting REE exports were located at different value steps in the supply chain network, as determined by their reported business lines. The 36 exporting respondents represented all 12 value step categories present in the full respondent sample.[10] Forty-six percent of respondents working in Distribution exported REE, representing the highest level of export participation within any value-step category. Of those working in Substitution or Financing as their primary business lines, 33 percent reported exporting. For those conducting Metallurgy, 29 percent reported exporting. In contrast, 10 percent of participants in Refining and Extraction reported exporting (see Figure VIII-13).

[10] These value steps were determined in Q1c.A of the assessment. BIS provided the list, with definitions that can be found in Appendix 1. Value Steps: Financing, Exploration, Extraction, Refining, Processing, Metallurgy, Manufacturing, Distribution, Recycling/Reclaim, Substitution, Research and Development, End Use/Application.

Figure VIII-13: Exporters of REEs by Value Step Participation



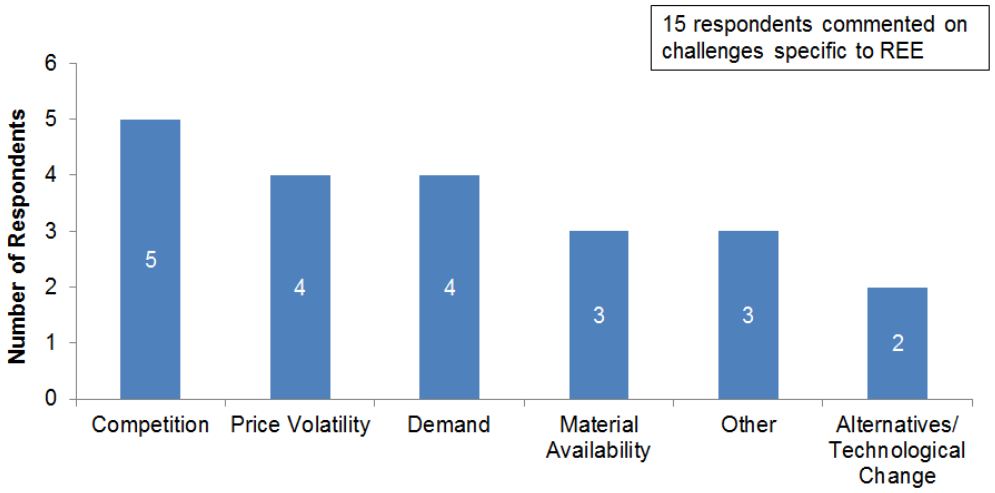
Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

BIS also collected data on the respondents' views of current and future trends in exporting REE products. One quarter of respondents (10 respondents) indicated that they planned to increase exports in the next five years. Of those respondents planning to increase their exports, three (33 percent) anticipated challenges to doing so. Whether or not respondents were planning to increase their exports, BIS asked them to identify the most anticipated current and/or future challenges to exporting DENTY or other REEs (see Figure VIII-15). 'Competition,' 'Price Volatility' and 'Demand' were the challenges most often cited, with five respondents listing 'Competition' and four respondents selecting 'Price Volatility' and 'Demand' each.

When asked to explain their choice of anticipated challenges to exporting REE products, respondents commented on a variety of challenges. One respondent commented, "The biggest challenge we face in the future for growing our business outside the US is competing against low Chinese RE alloy pricing levels." Another respondent commented, "In order to export REE-

related products, we need orders for them. Demand is miniscule. Can be expected to drift upward, but never be significant."

Figure VIII-14: Current and Anticipated Challenges to Exporting Rare Earth Elements



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

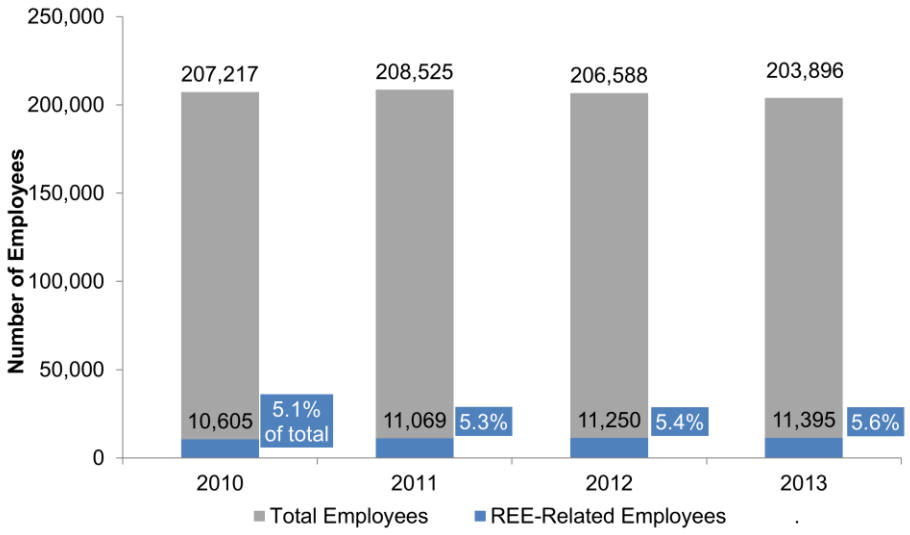
IX. EMPLOYMENT

Of the respondents' 203,896 total full time equivalent (FTE) employees, 11,395 (5.6 percent) performed REE-related duties.[11] Between the 2010 and 2013, total employee count remained relatively constant, decreasing by two percent overall. However, REE-related employee counts

[11] A full time equivalent (FTE) employee was defined as 40 person-hours of work. Two employees working 20 hours per week would constitute one FTE.

rose during the four-year time period, increasing by 10 percent, to 5.6 percent of total employment in 2013(see Figure IX-1).

Figure IX-1: Total and REE-Related Employment
2010-2013

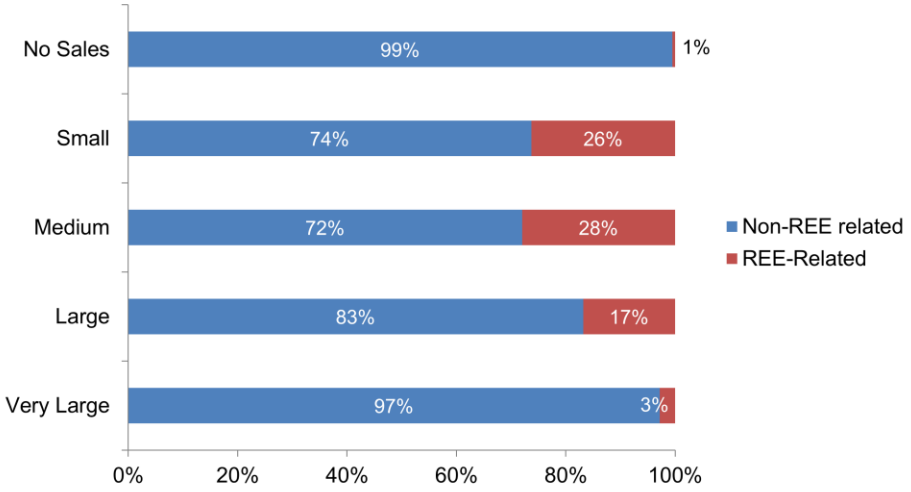


Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

For the most part, smaller companies dedicated a larger portion of their workforce to REE-related jobs. Twenty-six percent of small business workforces and 28 percent of medium-size business workforces were REE-related, compared to 17 percent of large business workforces. Very large businesses were even less focused on REEs, with three percent of their FTEs dedicated to REE-related business lines (see Figure IX-2).

Figure IX-2: REE-Related Employment by Size

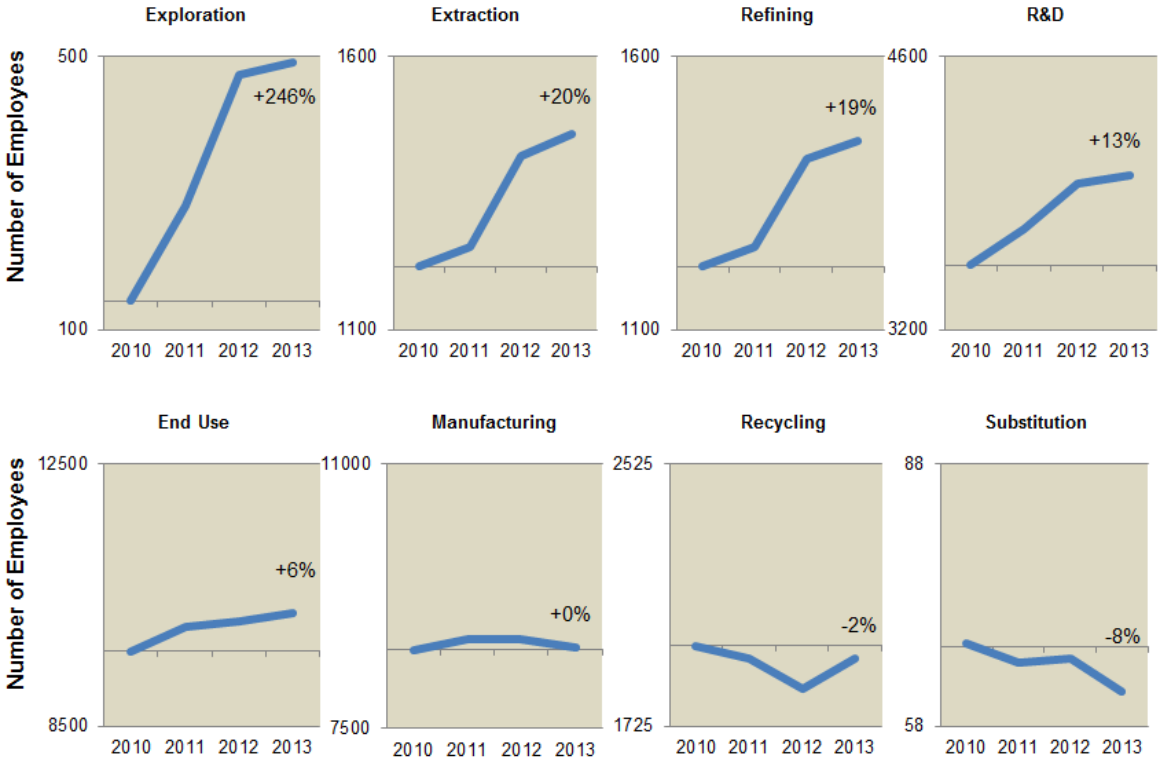
2013



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

Respondents in different business lines reported varying trends in REE-related employment, providing potential insight into expected areas of growth. Those respondents listing Exploration as one of their business lines reported very large increases in REE-related employment, with employment nearly tripling from 2010 to 2013 (see Figure IX-3). The next three business lines increasing REE-related employment were Extraction, Refining, and R&D with double digit increases over the four-year period. Decreases in employment among respondents working in Recycling and Substitution, may highlight global increases in REE demand and prices.

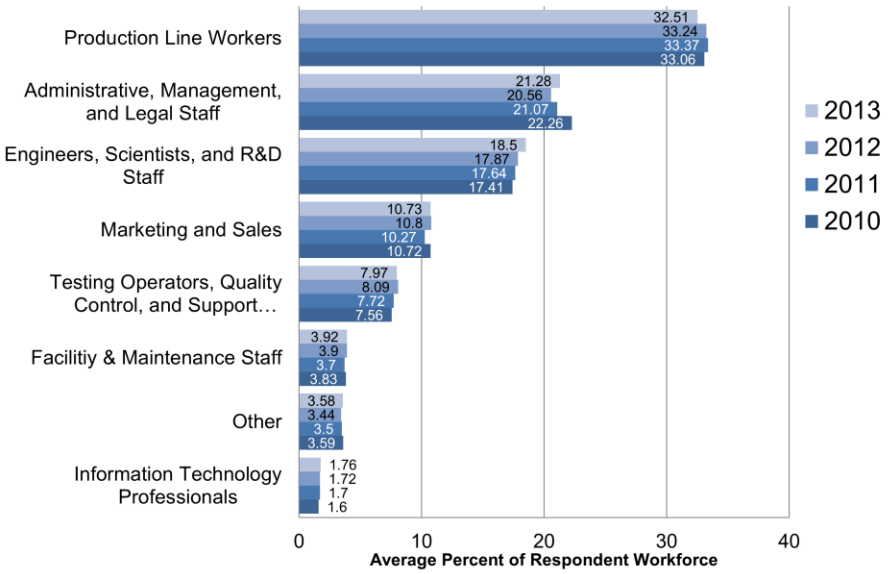
Figure IX-3: Change in REE-Related Employment by Select Business Lines*, 2010-2013



*Note: Respondents may participate in multiple business lines. Employee counts are not the number of workers devoted to the listed business line, but rather the number of workers employed by respondents participating in that business line.

BIS asked respondents to estimate the percentage of employees performing one of the listed professional occupation types, including an 'Other' category (see Figure IX-4). The percentage breakdown of employees in each occupation did not alter significantly during the 2010-2013 period. Production Line Workers constituted the largest workforce percentage, with an average of 33 percent of FTEs working in that occupation. An average of 21 percent of FTEs worked as Administrative, Management, and Legal Staff, followed by 18 percent working as Engineers, Scientists, and R&D staff. Other professional occupation categories included Market and Sales, Testing Operators, Facility & Maintenance Staff, and Information Technology (IT) Professionals.

Figure IX-4: Respondent Workforce by Professional Occupation



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

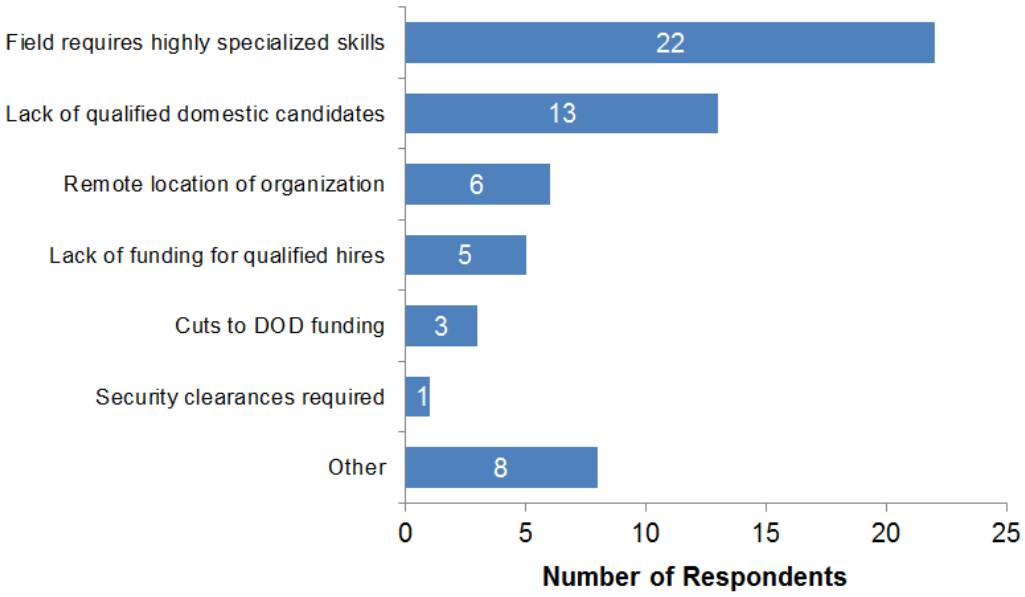
Thirty-five respondents (22 percent) reported difficulty hiring or retaining employees. These challenges were shared by respondents of all organization sizes, with very little variance in the percentage reporting difficulty. There was significantly more variance across business lines, with nearly half the respondents participating in Exploration, Extraction, or Refining reporting difficulty hiring or retaining workers, compared to just 15 percent of respondents engaged in Distribution. Reasons for hiring difficulties in these business lines were consistent across respondents, with trouble attracting people to their remote locations and finding workers with the required specialized skills.

Across all respondents, the leading reasons cited for difficulty in hiring or retaining employees were that respondents' particular fields required highly specialized skills and that there was a lack of qualified domestic candidates (see Figure IX-5). Many respondents included narrative explanations for these selections. According to one respondent, "There are only five colleges for

laser PhDs," while others also wrote of insufficient educational backgrounds, commenting "[There is a] lack of doctoral level training relevant to our lines of research," and noting the "Rare skill set of PhD level laser physicists."

Figure IX-5: Difficulty Hiring or Retaining Employees

35 respondents identified 58 reasons for having difficulty hiring or retaining employees



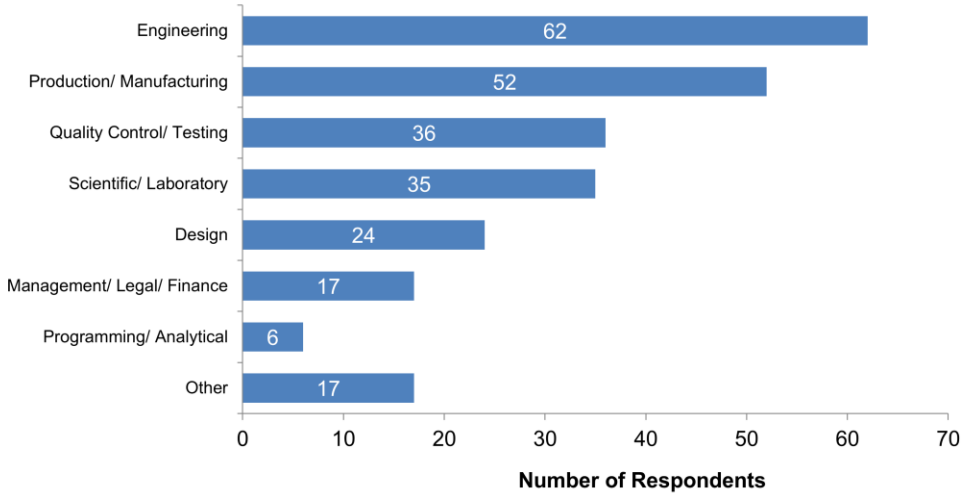
Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

BIS asked respondents to report up to five of the skills essential to their organizations' REE-related business lines.[12] Sixty-two respondents indicated Engineering as a key skill, and 52 indicated Production/Manufacturing (see Figure IX-6). Programming/Analytical skills (six respondents) were the least commonly selected skills category. Respondents provided narrative explanations for each selection, which often pointed towards much more specific skill sets within

[12] Listed Key Skills/Competencies: Design, Engineering, Management/Legal/Finance, Production/Manufacturing, Quality Control/Testing, Programming/Analytical, Scientific/Laboratory, Other

each category. For example, respondents who indicated 'Engineering' discussed ceramics, chemical processing, lasers, electro-optics, magnets, software, and safety, among other specializations. One respondent commented that REE-related business lines required engineering skills "beyond standard fiber production."

Figure IX-6: Skills Essential to Maintaining Rare Earth Element Business Lines



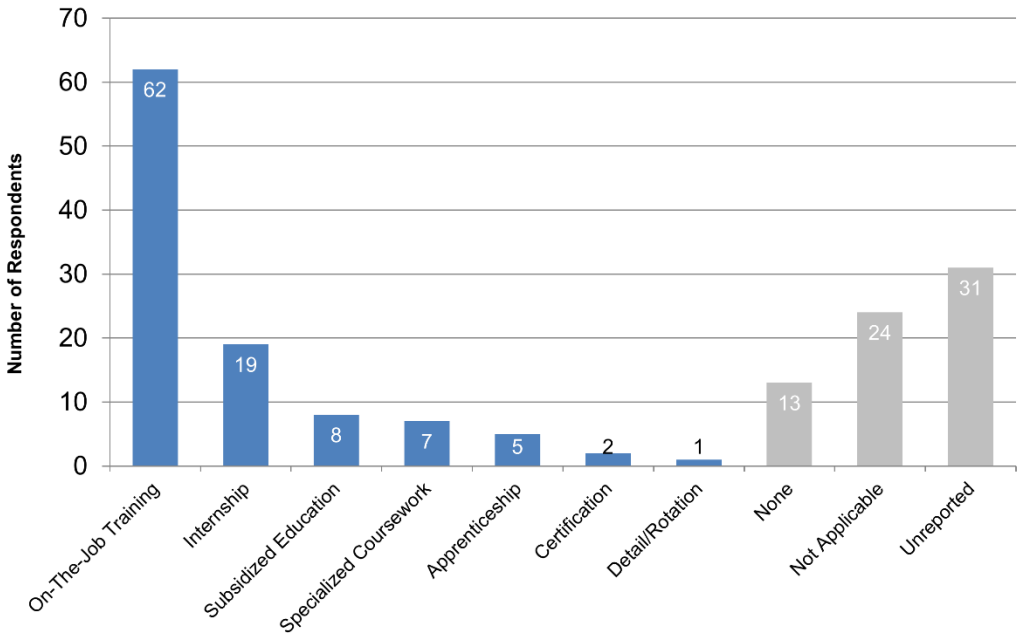
Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

To ease the difficulty in hiring and retaining employees with needed key skills, companies often engage in workforce development programs. BIS asked respondents to rank their preferred workforce development programs from a provided list.[13] Organizations most commonly preferred On-The-Job training (62 respondents, 36 percent) (see Figure IX-7). Internships (19

[13] Listed Workforce Development Programs: Apprenticeship, Certification, Detail/Rotation, Fellowship, Internship, On-The-Job Training, Reimbursement/Subsidized Education, Specialized Coursework

respondents, 11 percent), and Reimbursement/Subsidized Education (eight respondents, five percent) were the second and third-most selected development programs.

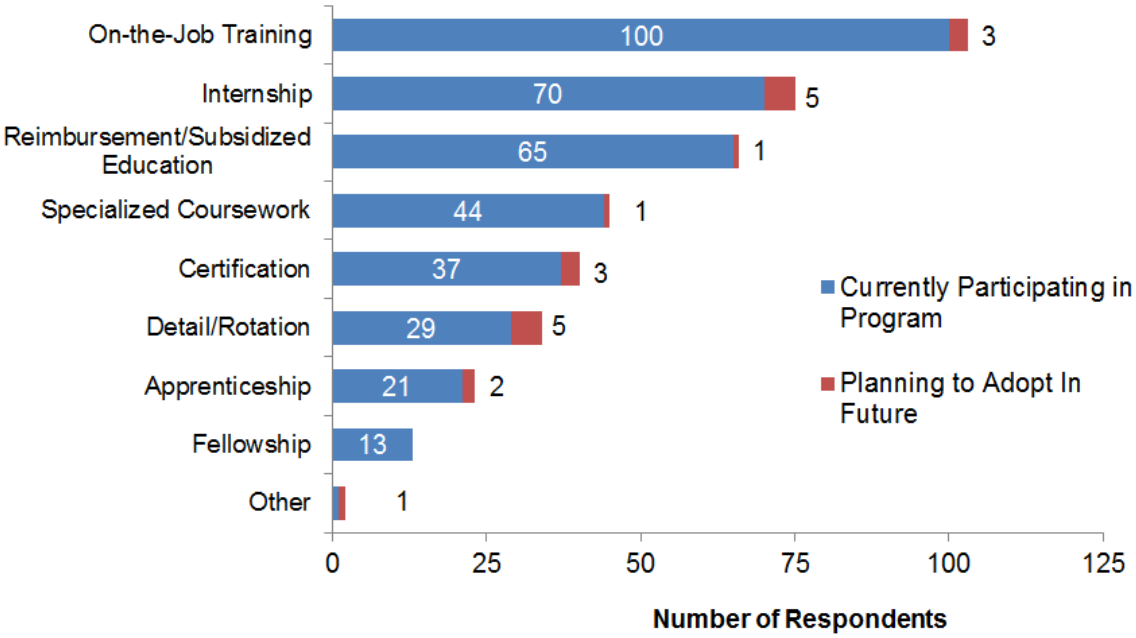
Figure IX-7: Preferred Workforce Development Programs



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

On-the-Job Training, Internships, and Reimbursement/Subsidized Education were also the highest in actual participation with 100 respondents (63 percent) identifying On-the-Job Training, 70 respondents (44 percent) identifying Internships, and 65 respondents (41 percent) identifying Reimbursement/Subsidized Education (see Figure IX-8). Respondents planned to adopt both Internships and Detail/Rotation (five respondents each) and Certification and On-the-Job Training (three respondents each) at the highest rates. At least one respondent planned to adopt each of the workforce development program types.

Figure IX-8: Workforce Development Program Participation and Future Plans



Source: U.S. Department of Commerce, Bureau of Industry and Security
Strategic Materials Assessment, Rare Earth Elements – 2016

X. FINDINGS

Industry Profile

- BIS received 160 survey responses representing each of the 12 identified steps of the value chain, from Exploration to Manufacturing and End-Use. One hundred forty of the respondents worked directly with the focus elements: Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium (DENTY).
- Most respondents were focused on Manufacturing, Distribution, End-Use/Application, and R&D; these four business lines accounted for 82 percent of the primary business lines selected by respondents.
- All 17 Rare Earth Elements (REEs) were used by respondents, from 115 respondents working with Neodymium to eight respondents working with Promethium. On average respondents worked with approximately six different REEs, though half worked with four or fewer, and 24 worked with just one REE – typically Neodymium or Cerium.
- Respondents supported a wide variety of application areas, with magnets, coatings, and ceramics being the most common.
- The 160 respondents reported operating 396 facilities in 38 states (288 facilities) and 33 non-U.S locations (108 facilities) between 2010 and 2013. Respondents had the greatest number of facilities in California, New Jersey, and New York. For the 108 facilities outside of the United States, most were in China, Germany, the UK, France, and Canada.

Sales and Financial Performance

- Aggregated sales of all respondents were $76.4 billion in 2013. REE-related products accounted for 8 percent of this amount – $6.1 billion – up from 5.8 percent in 2010. Sales growth in the commercial sector far outpaced that in the government sector.
- Forty-seven respondents reported decreased sales in 2013 from 2010, 30 of which experienced a sales decrease of more than 25 percent. Respondents with declining sales over the period were of all sizes, but nearly half were smaller organizations; 44.7 percent were categorized by BIS as small (less than $25 million in average annual sales).
- BIS developed a customized financial risk metric to portray the overall financial condition of respondents for 2010-2013. For the full period, three respondents were calculated to be at high/severe risk, with another 36 at moderate/elevated risk. On an annual basis, financial conditions deteriorated moderately, with the number of respondents categorized as low/neutral risk falling from 136 to 121.
- Respondents with moderate or high financial risk were significantly more likely to have decreased capital and R&D expenditures from 2010 to 2013 and slightly more likely to have reduced their workforce size over that period.

Products and Inputs

- The 160 respondents identified a total of 601 products or product types.
- Over two-thirds of the listed products were related to the DENTY elements; the majority of these products were magnets and magnet powder products.

- Nearly half of the products or services used Neodymium, which was used at over twice the rate of each of the other elements of focus (Dysprosium, Ytterbium, Erbium, and Terbium). Most products/services involved the use of more than one REE.
- Thirty-eight respondents identified 120 of their products/services they believed to be sole source. Neodymium products were most commonly identified as sole source, though at similar rates to Dysprosium-containing products. Products containing Terbium, Ytterbium, and Erbium were less frequently identified as sole source products.
- Respondents identified 618 inputs from 376 unique suppliers for their products.
- Respondents listed 24 inputs with sole source suppliers and 128 inputs with single source suppliers. Chemicals and Magnets had the greatest number of sole source and single source inputs. On a percentage basis, over three-quarters of Alloy and Ceramic inputs were sole or single source. Two input types had no known sole or single source suppliers listed: Lamps/Bulbs and Phosphors.
- REEs originating in China represented roughly two-thirds of these inputs, with those from the United States accounting for another 22 percent. All remaining countries accounted for just under 10 percent of known origin REEs, with no single country accounting for more than eight inputs.
- Supply chain disruptions were only a minor issue for respondents in 2012 and 2013. Seven respondents reported 16 total supply chain disruptions. Eleven of these disruptions were for suppliers located in China. China was the original source of REE for every one of the 16 inputs disrupted. The reasons given for

disruptions were varied, including legal holdups, quality issues, and significant price increases.

Organizational Challenges and Capital Expenditure

- Respondents ranked 'Foreign Competition' as their biggest organizational challenge, with 81 respondents identifying 'Foreign Competition as a challenge, and 30 noting it as their number one challenge, more than twice the number of the next most frequent primary challenge, 'Material Price Volatility.'
- Respondents were particularly concerned with Chinese competition, Chinese material price volatility, and non-U.S. material sustainability.
- Larger respondents tended to identify more challenges in general, listing an average of 10 organizational challenges, compared to seven for medium organizations and six for small organizations. Larger respondents were comparatively more concerned about 'Material Price Volatility' and 'Environmental Regulations', while smaller respondents reported more concern about 'Government Regulatory Burden', 'Export Controls/ITAR', and 'Labor Costs.'
- 'Aging Equipment, Facilities, or Infrastructure' was not a highly cited current challenge overall, but was the most frequently identified challenge expected to arise in the future.
- Respondents did not expect any major changes in the availability of any REEs in the near future. For every REE, the vast majority of respondents expected no

change in availability and in no cases did more expect a decrease in availability than an increase.

- Most respondents did not have REE-related capital expenditures; 35 respondents incurred REE-related capital expenditures, and a single respondent accounted for 75 percent of all REE-related capital expenditures.
- Respondents were most interested in learning more about USG assistance programs in Business Development and in Research and Development. A significant percentage also expressed interest in learning more about exporting, either via information on Global Export Opportunities or Export Licensing.

Innovation, Substitution, Recycling, and R&D

- Recycled products and inputs were twice as common as substituted products and inputs. Twenty-three percent of respondents recycled REEs or REE-related products, whereas eight percent of respondents substituted REEs with other REEs or non-REEs.
- Cost and expertise were cited as the most common constraints to recycling. Only one respondent believed implementing a new recycling program was feasible.
- Product Performance was the most frequently cited constraint to using recycled REEs or substituting for REEs.
- Among respondents not currently recycling, just four respondents believed implementing a recycling program would be extremely feasible, and another three believed it would be moderately feasible, while 54 said it would be difficult or impossible.

- Sixty-one respondents reported having REE-related R&D expenditures, totaling $254 million in 2013 – four percent of total R&D expenditures for all respondents.

Support for U.S. Government Agencies

- One hundred two of the respondents provided support to at least one USG agency, with USG sales accounting for nearly one-third of all sales in 2013. The Armed Services, NASA, and the Department of Energy were the most frequently supported agencies.
- Forty-seven respondents were potentially dependent on the USG, based on their indication as such and/or their percent of sales to the USG.
- Fifty-six percent of respondents supporting the USG provided support to more than one agency, and a quarter supported five or more.
- Respondents were far more vulnerable to variations in commercial demand than USG demand. Nearly half of all respondents indicated their commercial REE business was Moderately to Highly Vulnerable to variations in demand, while under one-quarter said the same of their USG defense-related REE business and 11 percent said this of their USG non-defense business.

Trade

- Sixty-six respondents indicated they imported REE-related ore, mixed compound, inorganic purified compound, organic purified compound, mixed metal, and/or purified metal between 2010 and 2013. Most importing respondents (46)

imported from a single country, with China accounting for 28 (61 percent) of these single country importers.

- Respondents reported a total of $1.1 billion worth of imports of REE-related ore, compounds, and metals from 2010 to 2013. The top three importers accounted for nearly $688 million of these imports (63 percent), and the top five accounted for 80 percent of imports.
- More than half of the respondents operating in Distribution or R&D business lines imported REEs, as did 43 percent of those in Manufacturing. Every other business line had less than 35 percent of its participants importing REEs.
- 36 respondents (23 percent) reported exports of REE-related ore, compound, or metal to 56 countries between 2010 and 2013. Another 36 respondents listed non-U.S. customers of their products or services.
- In no business line did more than half of the respondents export REEs or REE-related products. Only for Distribution did the proportion exporting exceed one-third.

Employment

- In 2013, the 160 respondents employed 203,896 total FTEs, 5.6 percent of whom performed REE-related duties. Smaller companies dedicated a larger portion of their workforce to REE-related jobs.
- The total number of employees decreased by two percent from 2010 to 2013, while the number of REE-related employees increased by 10 percent.

- Smaller companies tended to have a larger percentage of their workforce devoted to REE-related items. Small and medium sized businesses had 26 and 28 percent, respectively, of their employees working on REE-related items, compared to 17 percent for large and three percent for very large businesses.
- Respondents with Exploration, Extraction, Refining, and R&D business lines reported the largest increases in REE-related employment, while those with Recycling and Substitution business lines decreased their REE-related workforces.
- Thirty-five respondents (22 percent) reported difficulty hiring or retaining employees. Nearly half the respondents participating in Exploration, Extraction, or Refining reporting difficulty hiring or retaining workers, compared to just 15 percent of respondents engaged in Distribution.
- Engineering and Quality-Control/Testing were the top skills essential to organizations' REE-related business lines.
- On-the-Job Training, Internships, and Reimbursement/Subsidized Education were the most preferred and most utilized workforce development programs.

APPENDIX 1: Business Line Definitions

Term	Definition
Distributor/Distribution	An entity that buys noncompeting products or product lines, warehouses them, and resells them to retailers or directly to the end users or customers.
End-Use	The final application for which a product or service is intended or to which it is placed. This end use or application typically occurs downstream within the REE value chain.
Exploration	The process of locating ore to mine. This activity is an involved process that frequently utilizes prospecting services and constitutes a preliminary (upstream) step in the REE value chain.
Extraction	Mining or removal of materials and ores from the ground. There are two general types of extraction: sub-surface (deep) and surface.
Financing	The providing of capital for REE-related business activities, specifically for the exploration or extraction of REEs.
Manufacturer/ Manufacturing	An organization that uses labor and capital to convert raw materials and/or components into finished or semi-finished goods. For the purpose of this survey, manufacturing includes integration and assembly.
Metallurgy	The process of extracting a metal from its ore and then modifying that metal for use. This process produces alloys intended for sale or distribution.
Processing	A complex process that involves the separation and concentration of REEs from the host material/ore, reducing it to a pure metal in order to create a usable REE product.
Recycling/Reuse/ Recapture/Reclaim	Safely removing REE and REE-related inputs from finished goods for reuse in new products. For the purposes of this survey, REE recycling, reuse, recapture, and reclaim are used interchangeably.

Refining	Isolating individual REEs from Rare Earth Ores that have already been separated from waste products.
Research and Design (R&D)	Experimenting with and engineering new parts, chemicals, or processes essential to REE-related products/services that fall in other steps of the REE value chain.
Substitution	The act of replacing one REE or REE-related input with another REE/REE-related or non-REE related input.

Next Page

OMB Control Number: 0694-0119
Expiration Date: 31 December 2014

DEFENSE INDUSTRIAL BASE ASSESSMENT:
Strategic Materials - Rare Earth Elements - Dysprosium, Erbium, Neodymium, Terbium, Ytterbium

SCOPE OF ASSESSMENT

The U.S. Department of Commerce, Bureau of Industry and Security (BIS), Office of Technology Evaluation (OTE), in coordination with the Defense Logistics Agency (DLA) is conducting an industrial base survey and assessment of the supply chains associated with select critical and strategic materials required for key defense systems and platforms. This particular survey is focused on the Rare Earth Element (REE) industry, specifically the organizations and value chain supporting Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium-related products and services.

The primary goal of this assessment is to assist the defense community in understanding the health and competitiveness of critical material suppliers, and identify specific issues and challenges facing the industry. Consequently, agencies will be better informed to develop targeted planning and acquisition strategies to ensure the availability of the materials supply chain to support critical defense missions and programs.

RESPONSE TO THIS SURVEY IS REQUIRED BY LAW

A response to this survey is required by law (50 U.S.C. app. Sec. 2155). Failure to respond can result in a maximum fine of $10,000, imprisonment of up to one year, or both. Information furnished herewith is deemed confidential and will not be published or disclosed except in accordance with Section 705 of the Defense Production Act of 1950, as amended (50 U.S.C App. Sec. 2155). Section 705 prohibits the publication or disclosure of this information unless the President determines that its withholding is contrary to the national defense. Information will not be shared with any non-government entity, other than in aggregate form. The information will be protected pursuant to the appropriate exemptions from disclosure under the Freedom of Information Act (FOIA), should it be the subject of a FOIA request.

Not withstanding any other provision of law, no person is required to respond to nor shall a person be subject to a penalty for failure to comply with a collection of information subject to the requirements of the Paperwork Reduction Act unless that collection of information displays a currently valid OMB Control Number.

BURDEN ESTIMATE AND REQUEST FOR COMMENT

Public reporting burden for this collection of information is estimated to average 14 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information to BIS Information Collection Officer, Room 6883, Bureau of Industry and Security, U.S. Department of Commerce, Washington, D.C. 20230, and to the Office of Management and Budget, Paperwork Reduction Project (OMB Control No. 0694-0119), Washington, D.C. 20503.

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Previous Page Next Page

Table of Contents

I	General Instructions
II	Definitions
1	Organization Information
2	Products - Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium-related
3	Suppliers, Inventories, Inputs, and Sourcing
4	Government and Defense and Non-Defense Participation
5	Challenges and Organizational Outlook
6	Imports and Exports of REE-related Material
7	Sales
8	Customers
9	Financials
10	Employment
11	Research and Development
12	Capital Expenditures
13	U.S. Government Outreach Programs and Certification

Important Note:
Select dropdown menus in the survey are based on responses to previous sections.

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section I: General Instructions	
A	Your organization is required to complete this survey using an Excel template, which can be downloaded from the U.S. Department of Commerce, Bureau of Industry and Security (BIS) website: www.bis.doc.gov/REEsurvey. At your request, survey support staff will e-mail the Excel survey template directly to your organization. For your convenience, a PDF version of the survey is available on the BIS website to aid internal data collection. **Do not submit the PDF version of your organization's response to BIS.**
B	Respond to every question and carefully read the complete instructions for each section and subsection. This will help you distinguish more broad/aggregate REE-related questions versus more REE specific questions dealing strictly with Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium-related products and services. Surveys that are not fully completed will be returned for completion. Use comment boxes to provide any information to supplement responses provided in the survey form. Make sure to record a complete answer in the cell provided, even if the cell does not appear to expand to fit all the information. **Do not copy and paste responses within this survey.** Survey inputs should be made manually, by typing in responses or by use of a drop-down menu. The use of copy and paste can corrupt the survey template. If your survey response is corrupted as a result of copy and paste responses, a new survey will be sent to you for immediate completion.
C	**Do not disclose any classified information in this survey form.**
D	If information is not available from your organization's records in the form requested, you may furnish estimates.
E	Questions related to this survey should be directed to BIS survey staff at **REEsurvey@bis.doc.gov** or by calling survey support staff and team lead Jason Bolton at (202) 482-7808. E-mail is the preferred method of contact.
F	Upon completion, review, and certification of this Excel survey, transmit the survey via e-mail attachment to: **REEsurvey@bis.doc.gov**. Be sure to retain a copy for your records.
G	For questions related to the overall scope of this industrial base assessment, contact: Brad Botwin, Director, Industrial Studies Office of Technology Evaluation, Room 1093 U.S. Department of Commerce, BIS 1401 Constitution Avenue, NW Washington, DC 20230

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section II: Definitions	
Term	Definition
Alloy	A metal made by combining two or more metallic elements to give, for example, greater strength or resistance to corrosion.
Application	Integration/use of a REE-related material or product into/with a final good or service. This end use or application typically occurs downstream within the REE value chain.
Applied Research	Systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met. This activity includes work leading to the production of useful materials, devices and systems or methods, including design, development, and improvement of prototypes and new processes.
Authorizing Official	Executive officer of the organization or business unit or other individual who has the authority to execute this survey on behalf of the organization.
Basic Research	Systematic, scientific study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts.
Capacity Utilization Rate	The percent of an organization's potential output that is actually being used in current production, given the current number of shifts in operation.
Captive/Internal Capability	Capability retained within the organization, typically referred to as captive or internal capability.
Commercial and Government Entity (CAGE) Code	Commercial and Government Entity (CAGE) Code identifies companies doing or wishing to do business with the U.S. Federal Government. The code is used to support mechanized government systems and provides a standardized method of identifying a given facility at a specific location. Find CAGE codes at: http://www.logisticsinformationservice.dla.mil/BINCS/begin_search.aspx
Component	Any raw material, substance, piece, part, software, firmware, labeling, or assembly which is intended to be included as part of the finished, packaged, and labeled device.
Customer	An entity to which an organization directly delivers the product or service that the facility produces. A customer may be another company or another facility owned by the same parent organization. The customer may be the end user for the item but often will be an intermediate link in the supply chain, adding additional value before transferring the item to yet another customer.
Data Universal Numbering System (DUNS)	A nine-digit numbering system that uniquely identifies an individual business. Find DUNS numbers at: http://fedgov.dnb.com/webform
Direct Support	Product/service is provided by your organization directly to the specified customer, not through a third party (for example, prime contractor or distributor).
Distributor/Distribution	An entity that buys noncompeting products or product lines, warehouses them, and resells them to retailers or directly to the end users or customers.

Electromagnetic Separation	A milling method that separates rare earth bearing minerals from other materials within the mined ore using magnetic principals.
Electro-Transport Processing	REE refining technique, also known as "Electron Transfer," in which electrons move from one atom or a molecule to another.
End Use	The final application for which a product or service is intended or to which it is placed. This end use or application typically occurs downstream within the REE value chain.
Exploration	The process of locating ore to mine. This activity is an involved process that frequently utilizes prospecting services and constitutes a preliminary (upstream) step in the REE value chain.
Extraction	Mining or removal of materials and ores from the ground. There are two general types of extraction: sub-surface (deep) and surface.
Facility	A building or the minimum complex of buildings or parts of buildings in which a company operates to serve a particular function, producing revenue and incurring costs for the company. A facility may produce an item of tangible or intangible property or may perform a service. It may encompass a floor or group of floors within a building, a single building, or a group of buildings or structures. Often, a facility is a group of related locations at which company employees work, together constituting a profit-and-loss center for the company, and it may be identified by a unique DUNS number.
Federally Funded Research and Development Center (FFRDC)	Federally Funded Research and Development Centers that receive financing from the U.S. federal government and are administered by universities and corporations.
Financing	The providing of capital for REE-related business activities, specifically for the exploration or extraction of REEs.
Finished Product	Any product, or accessory to any product, that emerges from the manufacturing process which is suitable for use or capable of functioning, whether or not it is packaged or labeled.
Floatation Process/Froth Floatation	A process that selectively separates materials that lack an affinity for water (hydrophobic materials) from those that have an affinity for water (hydrophilic materials) using chemicals, compressed air, and water.
Full Time Equivalent (FTE) Employee	Employee who works for 40 hours in a normal work week. Convert part-time personnel to "full-time equivalents" by measuring their weekly work hours as a fraction of 40 hours, where two part-time employees working 20 hours per week would constitute one full-time equivalent.
Fractional Crystallization	A process that separates components of a solution (based on their different solubilities) by evaporating the solution until the component that is least soluble crystalizes and can be removed in its pure form from the solvent mixture.
Gravity Concentration	A process that separates materials of different specific gravity. Through a viscous fluid, this method exploits the variance in the material's gravity-driven movement. For this separation process to be successful, there has to exist a distinct difference between the gangue and the mineral.
Harmonized Tariff Schedule	10 digit codes used by the World Customs Organization in order to identify different products for international trade. The United States HTS code are used when importing goods into the United States.
Hydrometallurgy	A common extraction process that separates rare earth ore from mineral concentrates by using basic or acidic solutions in order to selectively dissolve and precipitate desired metals from a powder form that has been preprocessed. The specific method used depends on the metal that will be recovered, but options include selective precipitation, solvent extraction, leaching, among others.

Indirect Support	Third party (e.g., prime contractor or distributor) product/service sale and/or support to a specified party.
Inorganic Purified Compound	Compounds with no carbon-hydrogen (C-H) bonds. Inorganic Purified Compounds contain no impurities as a result of a refining/purification process.
Ion Exchange	A process in which fluid containing the wanted elements is mixed with elutriant and then poured over a resin. Molecules are separated on the basis of their affinity split between the resin and the elutriant.
Laser Gain	Material used as an amplification medium which transfers part of its energy to the emitted electromagnetic radiation. This material is a laser component that increases strength of the laser.
Manufacturer/Manufacturing	An organization that uses labor and capital to convert raw materials and/or components into finished or semi-finished goods. For the purpose of this survey, manufacturing includes integration and assembly.
Manufacturing Material	Any material or substance used in or used to facilitate the manufacturing process, a concomitant constituent, or a byproduct constituent produced during the manufacturing process, which is present in or on the finished device/product.
Material	A substance, element, or component of which something is made, can be made, or used in performing a particular activity.
Metallurgy	The process of extracting a metal from its ore and then modifying that metal for use. This process produces alloys intended for sale or distribution.
Milling/Beneficiation	Processes that remove the mineral ore from its host material. These processes include: floatation separators, electrical/magnetic separators, and gravity separators.
Mixed Compounds	To include: Concentrate; Chloride; Carbonate; Nitrate; Inorganic Rare-Earth Compounds; Organic Rare-Earth Compounds; Fluoride; Hydroxide; Oxide; Sulfate; and Rare-Earth Garnet.
Mixed Metals	To include: Mischmetal; Rare Earth Silicide; Rare Earth Metal; Mixed Metal Rare Earth Alloy; Didymium; Lanthanum Silicide; and Cerium Silicide.
North American Industry Classification System (NAICS) Code	North American Industry Classification System (NAICS) codes identify the category of product(s) or service(s) provided by your organization. Find NAICS codes at: http://www.census.gov/epcd/www/naics.html
Ore	A naturally occurring rock and/or mineral from which valuable materials are extracted. To include: Bastnaesite; Monazite; Xenotime; Eudialyte; Britholyte; Ancylite; Allanite; Churchite; Limorite; Kaisonite; Fergusonite; and Apatite.
Organic Purified Compounds	Compounds with at least one carbon-hydrogen (C-H) bond, with few exceptions. Organic Purified Compounds contain no impurities as a result of a refining/purification process.
Precious Metals	A classification of metals that have high economic value and/or are considered to be rare. Most commonly gold, silver, platinum, and palladium.
Processing	A complex process that involves the separation and concentration of REEs from the host material/ore, reducing it to a pure metal in order to create a usable REE product.
Product/Process Development	The process of designing/conceptualizing and developing a product prior to its production for customers.

Purified Metals	Metals that have no impurities as a result of a refining or purification process. To include: Lanthanum; Cerium; Praseodymium; Neodymium; Samarium; Europium; Gadolinium; Terbium; Dysprosium; Holmium; Erbium; Thulium; Ytterbium; Lutetium; Scandium, Yttrium; and Radioactive isotopes.
REE-Related	Maintaining a direct or indirect relationship or affiliation with any of the 17 REEs, to include the support of or participation in the REE value chain (e.g., financing, exploration, extraction, refining, processing, metallurgy, manufacturing, distribution, recycling/reclaim, substitution, research and development, and end use/application).
Primary/Original Source	The country of origin, meaning the country of initial mineral extraction or process step.
Programs	Includes, but is not limited to, acquisition categories (ACATs) and/or major defense acquisition programs (MDAPs).
Rare Earth Element (REE)	A category that includes element numbers 57-71 of the periodic table (Lanthanum, Cerium, Praseodymium, Neodymium, Promethium, Samarium, Europium, Gadolinium, Terbium, Dysprosium, Holmium, Erbium, Thulium, and Ytterbium) as well as Yttrium (39) and Scandium (21).
Recycling/Reuse/Recapture/Reclaim	Safely removing REE and REE-related inputs from finished goods for reuse in new products. For the purposes of this survey, REE recycling, reuse, recapture, and reclaim are used interchangeably.
REE Country of Origin	REE Country of Origin is the country location of the mine and/or initial supplier from which the REE contained in the REE Compound/Material Type was originally sourced.
Refining	Isolating individual REEs from Rare Earth Ores that have already been separated from waste products.
Research and Design	Experimenting with and engineering new parts, chemicals, or processes essential to REE-related products/services that fall in other steps of the REE value chain.
Service	An intangible product (contrasted to a good, which is a tangible product). Services typically cannot be stored or transported, are instantly perishable, and come into existence at the time they are bought and consumed.
Single Source	An organization that is designated as the only accepted source for the supply of parts, components, materials, or services, even though other sources with equivalent technical know-how and production capability may exist.
Small Business	Refer to the Small Business Administration's definitions for size requirements and disadvantaged small business qualifications. For size qualifications refer to: http://www.sba.gov/content/small-business-size-standards. For disadvantaged businesses refer to: http://www.sba.gov/content/disadvantaged-businesses.
Sole Source	An organization that is the only source for the supply of parts, components, materials, or services. No alternative U.S. or non-U.S. based suppliers exist other than the current supplier.
Solvent Extraction	Also known as liquid-liquid extraction, this method separates compounds by utilizing their relative solubilities within two immiscible liquids, usually an organic solvent and water.
STEM	STEM stands for Science, Technology, Engineering and Mathematics.
Sublimation	REE refinement technique in which REEs are transitioned directly from their solid states to a gaseous state which removes physical impurities.
Substitution	The act of replacing one REE or REE-related input with another REE/REE-related or non-REE related input.

Supplier	An entity from which your organization obtains inputs. A supplier may be another firm with which you have a contractual relationship, or it may be another facility owned by the same parent organization. The inputs may be goods or services.
Vacuum Casting	REE refinement technique that utilizes electric currents to melt metal within a vacuum.
United States	The "United States" or "U.S." includes the 50 states, Puerto Rico, the District of Columbia, the island of Guam, the Trust Territories, and the U.S. Virgin Islands.
Unalloyed Metal	A metal in its pure form, not combined with any other substance.
Utilization Rate	The fraction of an organization's potential output that is actually being used in current production, where potential output is based on a 7 day-a-week, 3x8-hour shift production schedule [100% utilization rate equals no downtime with full employment].
Zone Refining	A process to remove impurities within a material through ultra-purification techniques. This process uses pure inert atmosphere or high vacuum in order to prevent impurities from being picked up by the metal from the gaseous atmosphere.

Previous Page

Next Page

Section 1.a: Organization Information

A	From the dropdown, select the description that best identifies your organization:		
B	From the dropdown, indicate whether this survey response captures the operations of your whole organization or that of an individual business unit/division. Your organization may provide one corporate-level, consolidated response but all activities related to your Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium-related business lines must be reflected in the response. Note: All data in this survey response must be reported at the same organizational level.		

C	Provide the following information for the level at which your organization is responding to this survey.	
	Company/Organization Name	
	Business Unit/Division Name (if applicable)	
	Street Address	
	City	
	State	
	Country	
	Zip Code	
	Website	
	Phone Number	
	Primary DUNS Code for this Level (nine-digit number with no dashes)	
D	Provide the following information for your parent company, if applicable.	
	Company/Organization Name	
	Street Address	
	City	
	State	
	Country	
	Postal Code/Zip Code	
	Primary DUNS Code for Parent Company (nine-digit number with no dashes)	

E	From the dropdown, indicate whether your organization is publicly traded or privately held?		

F	Point of Contact regarding this survey:				
	Name	Title	Phone Number	E-mail Address	State

Comments:	

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Section 1.b: Organization Information

A

Identify all the market segments that your organization currently serves.

Consumer goods		
Construction/Building		
Electronics		
Batteries		
Lasers		
Magnets		
Optics/Sensors		
Semiconductors		
Other electronics (specify)		
Engineering		
Food/Agriculture		
Healthcare/Medical		
Industrial		
Chemical		
Energy/Power generation		
Flares		
Lamps/Bulbs		
Petrochemical		
Other industrial (specify)		
Marine Technology		
Materials		
Research and Development		
Telecommunication		
Transportation		
Aerospace		
Automotive		
Ships		
Rail		
Other transportation (specify)		
Space		
Launch		
Satellites		
Science		
Other space (specify)		
Other (specify)		

B

Identify all the defense-related market segments that your organization currently serves.

Aircraft		
Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR)		
Electronics		
Energy		
Ground Vehicles		
Missiles		
Research and Development		
Ships (surface and underwater)		
Space		
Other (specify)		

Comments:

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Section 1.c: Organization Information

A

From the list of REE value chain steps, select all applicable to your organization's business lines and/or current capabilities. (see definitions)

Identify as "primary" the single step representing your largest business line, by revenue, and/or current capability.

Then, identify as "additional" any other business lines and/or current capabilities related to the REE value chain.

Lastly, briefly describe both your primary and additional business line and/or current capability selections.

Financing		Processing		Recycling/Reclaim	
Exploration		Metallurgy		Substitution	
Extraction		Manufacturing		Research and Development	
Refining		Distribution		End Use/Application	
"Primary" (description)					
"Additional" (descriptions)					

B

Indicate whether your organization works with any of the identified REEs, whether in a mineral or precursor form (e.g., crystalline, powder, granules, or solution) or in an intermediate or final material application (e.g., alloy, laser gain, magnet, dopant, optical amplifier, etc.).

Cerium		Lanthanum		Scandium	
Dysprosium		Lutetium		Terbium	
Erbium		Neodymium		Thulium	
Europium		Praseodymium		Ytterbium	
Gadolinium		Promethium		Yttrium	
Holmium		Samarium		Other (specify)	
Other (description)					

C

Indicate whether your organization's current business lines and/or current capabilities support any of the identified REE application areas.

Alloys		Fiber		Nuclear	
Battery		Fiber Optics		Phosphors	
Carbon Arc Electrodes		Gain/Laser Medium		Polishing Powders	
Catalysts (e.g., cracking)		Garnet		Thick Films	
Cathode Ray Tubes		Glass Additives		Thin Films	
Cement		Klystrons		Traveling Wave Tubes	
Ceramics		Lamps/Bulbs		Other 1 (specify)	
Coatings		Light-Emitting Diodes		Other 2 (specify)	
Crystals (laser/non-laser)		Magnets and Magnet Powders		Other 3 (specify)	
Dopant		Metallurgical Additives		Other 4 (specify)	
Other 1 (description)					
Other 2 (description)					
Other 3 (description)					
Other 4 (description)					

D

Is your organization considered a small business as defined by the Small Business Administration? (see definitions)

For information on SBA's small business size standards, see: http://www.sba.gov/category/navigation-structure/contracting/contracting-officials/eligibility-size-standards

If yes, specify the type of small business (e.g., minority-owned, 8(a), etc.)

E

Provide the following identification codes, as applicable to your organization. (see definitions)

*Find your Commercial and Government Entity (CAGE) Codes at: http://www.logisticsinformationservice.dla.mil/BINCS/begin_search.aspx

**Find your North American Industry Classification System (NAICS) codes at: http://www.census.gov/epcd/www/naics.html

***Find your Harmonized Tariff Schedule (HTS) codes for REE-related imports and exports at: http://hts.usitc.gov/ or http://www.census.gov/foreign-trade/schedules/b/2014/

Commercial and Government Entity (CAGE) Code(s)*		Primary NAICS (6-digit) Code(s)**		Primary Harmonized Tariff Schedule Code(s) used for REE-related Imports and Exports (10-digit)***	
				Imports	Exports

Comments:

Previous Page

Next Page

Section 1.d: Organization Information

Identify all of your organization's U.S. and non-U.S. facilities with REE-related operations.

Provide the facility's name, location, and primary business line and/or current capability. Then, document the relevant REEs corresponding to each facility's operations.

Lastly, if applicable, specify any changes in REE-related operations that may impact the facility over the next five years.

		Location			Operations							Outlook	
	Facility Name (write-in)	City (write-in)	State	Country	Business Line/Current Capability (primary if multiple)	Dysprosium	Erbium	Neodymium	Terbium	Ytterbium	Other REE	Any operational changes anticipated over the next five years?	If yes, provide a brief explanation (write-in)
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Comments:	

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Previous Page

Next Page

Section 2.a: Products and Services Related to Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium

Describe all your organization's products and services related to Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium. These include finished items sold to external customers and semi-finished materials/inputs/precursors produced internally for sale and/or related production purposes.

For example, if your organization produces laser diodes but also the Erbium- or Ytterbium-doped laser gain crystal host material used for laser diode manufacture, both the laser diode and the laser media need be reported.

For each product/service you provide, record the Product/Service Name, whether a Product or Service, Type of Product/Service, and if you are a Sole Source. (see definitions)

Then, identify the relevant REE within each reported Product/Service, the REE Ore/Compound/Material Type (Ore, Mixed Compound, Inorganic Purified Compound, Organic Purified Compound, Purified Metal, Unknown, etc.) and the REE Refinement/Production Method, if applicable. (see definitions)

Note: If more than 30 REE-related products/services are offered by your organization, provide either a representative sample or the 30 most significant by revenue contribution.

	Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium-related Product/Service											
	Product/Service Name (write-in)	Product or Service	Type of Product/Service	Sole Source	Dysprosium	Erbium	Neodymium	Terbium	Ytterbium	Other REE	REE Ore/Compound/ Material Type (primary if multiple)	REE Refinement/ Production Method (primary if multiple)
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Comments:	

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Previous Page

Next Page

Section 2.b: Products and Services Related to Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium *continued*

Describe all your organization's products and services related to Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium by both End Use and Production and/or Distribution.

For each product/service indicate Sector End Use, Market Segment Served, Material Application, and provide a written description of End Use/Application.

Lastly, if applicable, provide the Average Annual and Maximum Annual Product Production and/or Distribution in both Number of Units and Kilograms. If figures are typically maintained in either Number of Units or Kilograms, and not both, either measurement is acceptable.

Note: Maximum Annual Production and/or Distribution assumes current capacity with no additional investments in property, plant, or equipment (PP&E) nor significant increases in personnel.

	Erbium, Neodymium, Terbium, and Ytterbium-Related Product/Service		End Use of Product/Service				Product Production and/or Distribution			
							Average Annual, since 2012		Maximum Annual	
	Product/Service Name Populated from 2.A Response	Type of Product/Service Populated from 2.A Response	Sector End Use (primary if multiple)	Market Segment Served (primary if multiple) Menu Populated from 1.B.a	Material Application (primary if multiple) Menu Populated from 1.C.c	End Use/Application Description (write-in)	Number of Units (write-in)	in Kilograms (write-in)	Number of Units (write-in)	In Kilograms (write-in)
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Comments:	

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Previous Page

Next Page

Section 3.a: Suppliers for Business Lines Related to Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium

Describe your organization's suppliers and inputs supporting your Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium-related business lines. Data should correspond to supplier procurements made since 2012.

Record the External Supplier's Name, Input Type, REE Ore/Compound/Material Type (Ore, Mixed Compound, Inorganic Purified Compound, Organic Purified Compound, Purified Metal, Unknown, etc.), and Input Description.

Then, provide up to five Dysprosium, Erbium, Neodymium, Terbium, and/or Ytterbium-related Products or Services associated with the reported input.

Note: Do not report internal, "same name" suppliers.
Note: If an individual supplier provides multiple inputs and/or supports more than five products or services, record the supplier name and corresponding information in an additional line.
Note: If more than 20 suppliers are used by your organization to support said products or services, provide either a representative sample or the 20 most significant by cost or value add.

	Supplier Name and Input Information				Product/Service Related to Input				
	External Supplier Name	Input Type	REE Ore/Compound/ Material Type (primary if multiple)	Input Description (write-in)	Product/Service 1 Menu Populated from 2.A	Product/Service 2 Menu Populated from 2.A	Product/Service 3 Menu Populated from 2.A	Product/Service 4 Menu Populated from 2.A	Product/Service 5 Menu Populated from 2.A
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Comments:

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Section 3.b: Suppliers for Business Lines Related to Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium *continued*

Describe your organization's suppliers and inputs supporting your Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium-related business lines. Data should correspond to supplier procurements made since 2012.

Record the supplier's State and Country of location, REE Country of Origin, if known, and Supplier Type. (see definitions)

Then, indicate whether the supplier is a Single/Sole Source and if an Alternative Supplier is available.

Note: REE Country of Origin is the country location of the mine and/or initial supplier from which the REE contained in the REE Compound/Material Type was originally sourced. Leave blank if unknown.

	Supplier Name and Input Information Populated from 3.A Response				Additional Supplier Information					
	External Supplier Name	Input Type	REE Ore/Compound/ Material Type	Input Description (write-in)	Supplier State	Supplier Country	REE Country of Origin (primary if multiple)	Supplier Type	Single/Sole Source	Alternative Supplier
1										
2										
3										
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Comments:	

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Previous Page

Next Page

Section 3.c: Inventory of Inputs Supporting Business Lines Related to Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium

Record the inventories of inputs corresponding to your organization's Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium-related business lines.

By Input Type and/or REE Compound/Material Type currently maintained in inventory, record the Number of Weeks of Inventory Currently Maintained, Number of Weeks Current Inventory would Last if Operating at 100% Capacity Utilization Rate, and Number of Weeks Required to Return Inventory to Current Levels if Suddenly Exhausted.

Then, indicate whether or not a Supply Disruption (since 2012) has occurred for each reported input.

Note: The Number of Weeks Required to Return Inventory to Current Levels if Suddenly Exhausted would occur at normal market prices and without preferential access to material.

	Input Information **Populated from 3.A**			Inventory Levels (in weeks)			Supply Disruption	
	Input Type	REE Ore/Compound/ Material Type	Input Description	Number of Weeks of Inventory Currently Maintained	Number of Weeks Current Inventory would Last if Operating at 100% Capacity Utilization Rate	Number of Weeks Required to Return Inventory to Current Levels if Suddenly Exhausted	Supply Disruption? (since 2012)	If yes, provide a brief description. (write-in)
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13								
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Comments:	

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Previous Page

Next Page

Section 3.d: Inputs and Sourcing of Materials

A	Does your organization utilize any of the identified materials in support of its Dysprosium, Erbium, Neodymium, Terbium, and/or Ytterbium-related business lines? If no, proceed to Section 4.	

B

If yes, indicate whether or not each critical material supports your REE or Non-REE-Related business lines, in addition to your specific Dysprosium, Erbium, Neodymium, Terbium, Ytterbium and/or Other REE-related business lines.

Then, for each material indicate if you are Concerned about Material's Availability to Support Ongoing Operations and whether or not Supply Disruption (since 2012) has occurred.

Finally, identify both the Type and Location of the material's Direct/Immediate Source while also declaring the Primary/Original Source. (see definitions)

Material	Operational Use							Sourcing Problems		Direct/Immediate Source		Primary/Original Source (country)
	Supports REE or Non-REE-Related Business Lines?	Dysprosium	Erbium	Neodymium	Terbium	Ytterbium	Other REE	Concerned about Material's Availability to Support Ongoing Operations?	Supply Disruption? (since 2012)	Type	Location (country)	
Aluminum												
Ceramics (specify)												
Composites (specify)												
Cobalt												
Copper												
Gallium												
Gold												
Iron												
Lead												
Lanthanides (specify)												
Lithium												
Magnesium												
Molybdenum												
Nickel												
Niobium												
Palladium												
Platinum												
Rare Earth Elements (REE)												
Silicon												
Silver												
Steel - Alloys (specify)												
Steel - Carbon (specify)												
Steel - Stainless (specify)												
Steel - Tool (specify)												
Tantalum												
Tin												
Titanium												
Tungsten												
Vanadium												
Zinc												
Zirconium												
Other 1 (specify)												
Other 2 (specify)												
Other 3 (specify)												

C	Describe your concerns over the availability of such critical materials as well as any steps your organization has recently taken to minimize future disruptions and/or risks to supply.	
	Comments:	

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Section 4.a: U.S. Government Defense and Non-Defense Participation

Describe your organization's dependency on U.S. Government defense and non-defense demand for the sustainment of its REE-related products and services, to include Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium-related products and services.

A

How vulnerable are your REE-related business lines to variability in:	Type of Business Line: REE-related	Type of Business Line: Non-REE-related	Comments
U.S. Government defense demand?			
U.S. Government non-defense demand?			
Non-government demand?			

If there is a sudden or steep decline in U.S. Government demand for REE-related products and/or services, can your organization readily convert its relevant government business lines to commercial ones?	
Estimate the percentage of your current U.S. Government REE-related products and/or services that are readily compatible with non-government business lines.	

B

Does your organization consider itself dependent upon U.S. Government programs for its continued viability? Explain your response.	
Explanation:	
If your organization's REE-related business lines support Department of Defense (DOD) programs, whether directly or indirectly, are those business lines integrated or separate from your commercial-based operations? Explain your response.	
Explanation:	
Is your organization capable of simultaneously supporting DOD and commercial requirements? Explain your response.	
Explanation:	

C

Identify the impacts that a sudden decrease or increase in U.S. Government demand, whether direct or indirect, for your REE-related business lines would have on your organization.

Business Operation	Impact of decreased U.S. Government demand for your organization's REE-related business lines	Impact of increased U.S. Government demand for your organization's REE-related business lines
Capital expenditures		
Number of key REE-related production machinery/equipment		
Number of personnel with key skills		
Number of REE-related product/service lines		
Organization viability or solvency		
Product/service development cost		
Product/service price		
Pursuit of non-U.S. customers		
Pursuit of REE-related operations in non-U.S. locations		
Pursuit of U.S. Government contracts		
Pursuit of U.S.-located customers		
Research and Development expenditures		
Sales-based revenue		
Other 1 (specify)		
Other 2 (specify)		

D

From 2010-2014, has your organization received a rated order (DO or DX) from a U.S. Government agency and/or affiliated contractor? A rated order means a prime contract, a subcontract, or a purchase order in support of an approved program issued in accordance with the provisions of the Defense Priorities and Allocation System (DPAS) regulations (15 CFR part 700).	

Comments:	

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Previous Page

Next Page

Section 4.b: U.S. Government Defense and Non-Defense Participation

A	Since 2010, has your organization directly or indirectly supported any U.S. Government agencies or programs in any capacity? If directly, indirectly, or both, complete subsections B and C. If no, proceed to Section 5.							
B	From the list of U.S. Government agencies, select those your organization has supported since 2010. If you support an additional agency, identify said agency in "Other."							
	U.S. Air Force		U.S. Intelligence Community (e.g., CIA, NGA, NRO, NSA)		Department of Energy (DOE)			
	U.S. Army		Missile Defense Agency (MDA)		Defense Logistics Agency (DLA)			
	U.S. Marine Corps		National Aeronautics and Space Administration (NASA)		Other Agency 1			
	U.S. Navy		National Oceanic and Atmospheric Administration (NOAA)		Other Agency 2			

C

Identify the specific U.S. Government Programs/Systems your organization has supported since 2010 with its Dysprosium, Erbium, Neodymium, Terbium, and/or Ytterbium-related business lines.

Record both the Government Program/System Name and the corresponding Agency Name. Make sure to spell out all acronyms, when applicable.

Then, provide up to six products/services affiliated with your Dysprosium, Erbium, Neodymium, Terbium, and/or Ytterbium-related business lines.

Note: If unsure of the specific U.S. Government Programs/System Name or Agency Name, provide as much information as possible.

	Government Program/System Name (write-in)	Agency Name Menu Populated from 4.b.B	Product/Service 1 Menu Populated from 2.A	Product/Service 2 Menu Populated from 2.A	Product/Service 3 Menu Populated from 2.A	Product/Service 4 Menu Populated from 2.A	Product/Service 5 Menu Populated from 2.A	Product/Service 6 Menu Populated from 2.A
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Comments:	

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section 5.a: Challenges and Organizational Outlook - Issues

Identify the issues impacting your organization's REE-related business lines, indicating whether currently, in the future, or both, to include its Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium-related business lines.

Then, rank the top five issues (1 = Most Important; 5 = Least Important) by writing in numbers 1-5 next to only the leading five issues. Each number should be recorded only once and placed next to a "Current," "Future," or "Both" response.

Lastly, provide an explanation of your top five issues.

A

	Type of Issue	Impact?	Rank Top 5	Explanation
1	Aging equipment, facilities, or infrastructure			
2	Availability of capital			
3	Domestic competition			
4	Environmental regulations/remediation			
5	Export controls/ITAR			
6	Foreign competition			
7	Government purchasing volatility			
8	Government regulatory burden			
9	Healthcare			
10	Illegal rare earth mining/smuggling			
11	Labor availability			
12	Labor costs			
13	Material price volatility			
14	New production methods			
15	Non-U.S. material availability			
16	Non-U.S. supplier reliability			
17	Patent infringement			
18	Pension costs			
19	Proximity to customers			
20	Proximity to suppliers			
21	Reduction in U.S. government demand			
22	REE design-out/substitution			
23	Qualifications/certifications			
24	Quality of inputs			
25	Research and development costs			
26	Taxes			
27	U.S. material availability			
28	U.S. supplier reliability			
29	Worker/skills retention			
30	Other (specify)			

Comments:	

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section 5.b: Challenges and Organizational Outlook - Competitiveness

Describe your organization's competitiveness and any challenges to the sustainment of its REE-related business lines, to include its Dysprosium, Erbium, Neodymium, Terbium, and/or Ytterbium-related business lines.

A — Identify key actions your organization has taken and is planning to take to improve its overall competitiveness. Explain your selections.

		Actions Taken Since 2010	
		Action	Explanation
1	i		
	ii		
	iii		

		Actions Planned for Next Five Years	
		Action	Explanation
2	i		
	ii		
	iii		

B

1	Does your organization face any supply chain constraints related to the procurement of REEs or REE-related product/services?	
	If yes, do you foresee such supply chain constraints affecting your organization's future operations? Explain your responses.	
	Explanation:	
2	Do you anticipate that an increase in the supply or ready availability of U.S. mined REEs will make your organization more competitive in the marketplace? Explain your response.	
	Explanation:	
3	If both domestic and non-U.S. aggregate demand for REEs and REE-related products/services increases, will your organization benefit? Explain your response.	
	Explanation:	

C — How would the following scenarios affect the sustainment of your organization's REE-related business lines? Rank 1 -5 the impact of each scenario on your ability to maintain your REE-related business lines (1 = Negative Long-Term Impact; 5 = Positive Long-Term Impact). Explain your selections.

1	Elimination/softening by China of its export quota restrictions regarding REEs and REE-related products:		Explanation:	
2	Imposition of more stringent production controls on China's REE-related mining practices:		Explanation:	
3	Prosecution of companies distributing and/or using illegally produced REE-related materials:		Explanation:	
4	Increase in both U.S. imports and overall supply of REEs and REE-related products:		Explanation:	
5	Decrease in the number of U.S. located suppliers for REEs and REE-related products:		Explanation:	
6	Rules/regulations adopted by the U.S. Government requiring industry's recycling of REEs and REE-related products:		Explanation:	
7	Increase by the U.S. Government of both type and volume of REEs and REE-related products identified for stockpiling:		Explanation:	

D — For application in your organization's current operations, indicate whether you expect an Increase, Decrease, or No Change in the availability of each REE in the next 12-24 months.

Cerium		Lanthanum		Scandium	
Dysprosium		Lutetium		Terbium	
Erbium		Neodymium		Thulium	
Europium		Praseodymium		Ytterbium	
Gadolinium		Promethium		Yttrium	
Holmium		Samarium		Other	
Other (description)					

Comments:	

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Previous Page Next Page

Section 5.c: Challenges and Organizational Outlook - Recycling

Recycling and Use of Recycled Rare Earth Elements

The safe removal of REE and REE-related inputs from finished goods for reuse in new products, also known as recycling, is a process of increasing relevance in the REE supply chain.

For the purposes of this survey, "recycle" includes reuse, recapture, and reclaim.

Respond to the following question concerning your organization's REE-related recycling practices.

A	1	Does your organization recycle REEs or REE-related products?	
	2	If no, does your organization plan to recycle REEs or REE-related products in the next 5 years?	
	3	If no, identify the primary constraint prohibiting your organization's recycling of REEs or REE-related products. Explain your selection.	
		Explanation:	
	4	If no, indicate the feasibility of recycling REEs or REE-related products. Rank feasibility 1-5, where 1 = Feasible/Evident; 5 = Impossible/Not Applicable.	

Use of Recycled Rare Earth Elements

B	1	Does your organization use recycled REEs or REE-related products within your operations?	
	2	If no, does your organization plan to use recycled REEs or REE-related products in the next 5 years?	
	3	If no, identify the primary constraint prohibiting your organization's use of recycled REEs or REE-related products. Explain your selection.	
		Explanation:	
	4	If no, indicate the feasibility of using recycled REEs or REE-related products in your current business lines. Rank feasibility 1-5, where 1 = Feasible/Evident; 5 = Impossible/Not Applicable.	

Rare Earth Element Recycling Processes

C		Describe the REE-related recycling processes adopted by your organization.	
	1	By volume of recycled material, what is the primary recycling technique or process adopted (or planned) by your organization for recycling REEs or REE-related products? Explain your selection.	
		Explanation:	
	2	Has (or will) the recycling of REEs or REE-related products improve your organization's overall competiveness, e.g., improved product quality or performance, increased margins, reduced lead times, etc.? Explain your response.	
		Explanation:	

Comments:	

Section 5.d: Challenges and Organizational Outlook - Substitution

Substitution of Rare Earth Elements			
The act of replacing a REE or REE-related input with another input, also known as substitution, is a process of increasing relevance in the REE supply chain. Respond to the following questions concerning REE substitution practices and their application to your organization's REE-related business lines, to include its Dysprosium, Erbium, Neodymium, Terbium, and/or Ytterbium-related business lines.			
A	1	Does your organization substitute REEs with different REEs or non-REE materials?	
	2	If no, does your organization plan to substitute REEs with different REEs or non-REE materials in the next 5 years?	
	3	If no, identify the primary constraint prohibiting your organization's substitution of REEs with different REEs or non-REE materials. Explain your selection.	
		Explanation:	
	4	If no, indicate the feasibility of REE substitution at your organization. Rank feasibility 1-5, where 1 = Feasible/Evident; 5 = Impossible/Not Applicable.	
Use of REE Substitutes/Related Products			
B	1	Does your organization use products containing REE substitutes?	
	2	If no, does your organization plan to use products containing REE substitutes in the next 5 years?	
	3	If no, identify the primary constraint prohibiting your organization's use of products containing REE substitutes. Explain your selection.	
		Explanation:	
	4	If no, indicate the feasibility of using REE substitute or products containing REE substitutes in your current business lines. Rank feasibility 1-5, where 1 = Feasible/Evident; 5 = Impossible/Not Applicable.	
Rare Earth Element Substitution Processes			
C		Describe the REE-related substitution processes adopted by your organization.	
	1	By volume of material or product subject to REE substitution, what is the primary substitution technique or process used (or planned) by your organization? Explain your selection.	
		Explanation:	
	2	Has (or will) the substitution of REEs improve your organization's overall competiveness, e.g., improved product quality or performance, increased margins, reduced lead times, etc.? Explain your response.	
		Explanation:	
		Comments:	

Section 6.a: Imports of Dysprosium, Erbium, Neodymium, Terbium, Ytterbium, and Other REE-related Material

A Since 2010, has your organization imported into the United States any Dysprosium, Erbium, Neodymium, Terbium, Ytterbium, and/or Other REE-related Ore, Mixed Compound, Inorganic Purified Compound, Organic Purified Compound, Mixed Metal, and/or Purified Metal? (see definitions)

If no, continue to Section 6.b. If yes, complete sub-sections B and C.

B Recorded data should reflect only United States-based imports of Dysprosium, Erbium, Neodymium, Terbium, Ytterbium, and/or Other REE-related Ore, Mixed Compound, Inorganic Purified Compound, Organic Purified Compound, Mixed Metal, and/or Purified Metal transacted from 2010 through 2013.

First, select the countries from which your organization has imported Dysprosium, Erbium, Neodymium, Terbium, Ytterbium, and/or Other REE-related material.

Then, identify the REE Ore/Compound/Material Type imported from each Country. If multiple Ores/Compounds/Material Types are imported from a single country, record all corresponding information in an additional line.

Lastly, by Country and corresponding REE Ore/Compound/Material Type, record the Total Quantity Imported between 2010-2013, Quantity Unit of Measure, and Total Value Imported (in USD Thousands) between 2010-2013.

Country	REE Imported: Dysprosium	Erbium	Neodymium	Terbium	Ytterbium	Other REE	REE Ore/Compound/ Material Type	Total Quantity Imported in 2010-2013 (write-in)	Quantity Unit of Measure: Ounces, Pounds, Tons, Grams, Kilograms, or Metric Tons	Total Kilograms Imported in 2010-2013 (auto-calculated)	Total Value Imported in 2010-2013 **in $ Thousands** **$12,000.00 = survey input of $12**
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	

C

1	Does your organization anticipate increasing its imports of Dysprosium, Erbium, Neodymium, Terbium, Ytterbium and/or Other REE-related material over the next 5 years?	
2	If yes, does your organization anticipate any challenges to increasing its imports of Dysprosium, Erbium, Neodymium, Terbium, Ytterbium and/or Other REE-related material?	
3	Explain current and/or future challenges your organization faces when importing Dysprosium, Erbium, Neodymium, Terbium, Ytterbium and/or Other REE-related material.	
	Explanation:	

Comments:

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section 6.b: Exports of Dysprosium, Erbium, Neodymium, Terbium, Ytterbium, and Other REE-related Material

A

Since 2010, has your organization exported from the United States any Dysprosium, Erbium, Neodymium, Terbium, Ytterbium, and/or Other REE-related Ore, Mixed Compound, Inorganic Purified Compound, Organic Purified Compound, Mixed Metal, and/or Purified Metal? (see definitions)

If no, continue to Section 7. If yes, complete sub-sections B and C.

B

Recorded data should reflect only United States-based exports of Dysprosium, Erbium, Neodymium, Terbium, Ytterbium, and/or Other REE-related Ore, Mixed Compound, Inorganic Purified Compound, Organic Purified Compound, Mixed Metal, and/or Purified Metal transacted from 2010 through 2013.

First, select the countries in receipt of your organization's exports of Dysprosium, Erbium, Neodymium, Terbium, Ytterbium, and/or Other REE-related material.

Then, identify the REE Ore/Compound/Material Type exported to each Country. If multiple Ores/Compounds/Material Types are exported to a single country, record all corresponding information in an additional line.

Lastly, by Country and corresponding REE Ore/Compound/Material Type, record the Total Quantity Exported between 2010-2013, Quantity Unit of Measure, and Total Value Exported (in USD Thousands) between 2010-2013.

Country	REE Exported: Dysprosium	Erbium	Neodymium	Terbium	Ytterbium	Other REE	REE Ore/Compound/ Material Type	Total Quantity Exported in 2010-2013 (write-in)	Quantity Unit of Measure: Ounces, Pounds, Tons, Grams, Kilograms, or Metric Tons	Total Kilograms Exported in 2010-2013 (auto-calculated)	Total Value Exported in 2010-2013 **in $ Thousands** **$12,000.00 = survey input of $12**
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	
										0	

C

1. Does your organization anticipate increasing its exports of Dysprosium, Erbium, Neodymium, Terbium, Ytterbium and/or Other REE-related material over the next 5 years?
2. If yes, does your organization anticipate any challenges to increasing its exports of Dysprosium, Erbium, Neodymium, Terbium, Ytterbium and/or Other REE-related material?
3. Explain current and/or future challenges your organization faces when exporting Dysprosium, Erbium, Neodymium, Terbium, Ytterbium and/or Other REE-related material.

Explanation:

Comments:

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Previous Page

Next Page

Section 7: Sales

Provide your U.S.-based operation's 2010-2013 U.S. and Non-U.S. sales information.

Record your Total U.S. and Non-U.S. Sales, all Customers, and a percentage breakout by both Non-Government and Government Sales in lines 1 and 2 (should sum to 100%).

Then, record your Total U.S. and Non-U.S. REE-related Sales, all Customers, to include Dysprosium, Erbium, Neodymium, Terbium, Ytterbium, and Other REE-related Sales, and a percentage breakout by REE-related Non-Government and REE-related Government Sales in lines 1 and 2 (should sum to 100%).

Lastly, provide a percentage breakout of your U.S. Government REE-related Government Sales by both U.S. Government Defense and Non-Defense Sales in lines i and ii (should sum to 100%).

For 2014, estimate the percentage change from 2013 in Total U.S. and Non-U.S. Sales, Total U.S. and Non-U.S. REE-related Sales, and U.S. Government REE-related Defense and Non-Defense Sales.

*Government Sales include both direct and indirect sales to government customers (including sales to prime contractors with government program application). All sales with government end uses should be reported as Government Sales.

Note: Ensure your "Source of Sales Data" declaration is consistent with your response in Section 1.a. This means that if you declared the survey response to be a Business Unit/Division-level response in Section 1.a then this section should contain Business Unit/Division-level data.

Source of Sales Data:	
Reporting Schedule:	

"U.S." means U.S. domestic sales; "Non-U.S." means export sales from U.S. locations			Record in $ Thousands, e.g. $12,000.00 = survey input of $12								Record as Percent Change from 2013	
			2010		2011		2012		2013		2014	
			U.S.	Non-U.S.	U.S.	Non-U.S.	U.S.	Non-U.S.	U.S.	Non-U.S.	U.S.	Non-U.S.
A	Total Sales, all Customers											
	1	Total Non-Government Sales [as a % of line A]										
	2	*Total Government Sales [as a % of line A]										
	Lines 1 and 2 must sum to 100%		0%	0%	0%	0%	0%	0%	0%	0%		
B	Total REE-related Sales, all Customers											
	1	REE-related Non-Government Sales [as a % of line B]										
	2	*REE-related Government Sales [as a % of line B]										
	Lines 1 and 2 must sum to 100%		0%	0%	0%	0%	0%	0%	0%	0%		
	i	*REE-related U.S. Government Defense Sales [as a % of line B.2]										
	ii	*REE-related U.S. Government, Non-Defense Sales [as a % of line B.2]										
	Lines i and ii must sum to 100%		0%		0%		0%		0%			

C

1 Does your organization consider itself dependent on its REE-related sales for its ongoing viability? Explain your response.

Explanation:

2 Indicate the degree of compatibility between your REE and non-REE business lines and/or operations by estimating the percentage of your current REE-related business lines/operations that can be readily converted to non-REE-related business lines/operations. Explain your response.

Explanation:

Comments:

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Previous Page

Next Page

Section 8: Customers

Identify your organization's leading direct customers for Dysprosium, Erbium, Neodymium, Terbium, and Ytterbium-related business lines based on average annual sales in 2010-2013.

Provide the Direct Customer's Name, indicating both the Type of Customer and corresponding Market Segment of Customer.

Then, record the leading Products/Services sold and the Customer's Location (City, State, Country).

Lastly, for each customer estimate the Average Annual Total Sales (in U.S. dollar thousands) from 2010-2013.

A

	Customer Profile			Product/Service			Customer Location			Sales (USD)
	Direct Customer Name (write-in)	Type of Customer	Market Segment of Customer (primary if multiple) Menu Populated from 1.B.a	REE Product/Service 1 Menu Populated from 2.A	REE Product/Service 2 Menu Populated from 2.A	REE Product/Service 3 Menu Populated from 2.A	City (write-in)	State	Country	Average Annual Sales in $ Thousands $12,000.00 = survey input of $12
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										

Comments:

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section 9: Financials

Report line items from your organization's financial statements for years 2010-2013.

Indicate whether the reported income statement and balance sheet line items are Business Unit/Division or Corporate/Whole Organization financials.

Note: Ensure your "Source of Sales Data" declaration is consistent with your response in Section 1.a. This means that if you declared the survey response to be a Business Unit/Division-level response in Section 1.a then this section should contain Business Unit/Division-level data.

Source of Financial Line Items:	
Reporting Schedule:	

	Income Statement (Select Line Items)	Record in $ Thousands, e.g. $12,000.00 = survey input of $12			
		2010	2011	2012	2013
A	Net Sales (and other revenue)				
B	Cost of Goods Sold				
C	Total Operating Income (Loss)				
D	Earnings Before Interest and Taxes				
E	Net Income				

	Balance Sheet (Select Line Items)	Record in $ Thousands, e.g. $12,000.00 = survey input of $12			
		2010	2011	2012	2013
A	Cash				
B	Inventories				
C	Total Current Assets				
D	Total Assets				
E	Total Current Liabilities				
F	Total Liabilities				
G	Retained Earnings				
H	Total Owner's Equity*				

* Total Owner's Equity (line H in the Balance Sheet) should equal Total Assets less Total Liabilities

Comments:	

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section 10: Employment

Record the total number of full-time equivalent (FTE) employees in your organization's U.S.-based operations for the 2010-2013 period.

Then, estimate the percentage of these employees that perform the professional occupations indicated.

Do not double count personnel who may perform cross-operational roles. Estimates are encouraged.

Note: Ensure your "Source of Workforce Data" declaration is consistent with your response in Section 1.a. This means that if you declared the survey response to be a Business Unit/Division-level response in Section 1.a then this section should contain Business Unit/Division-level data.

Source of Workforce Data:						
Reporting Schedule:						
A		Professional Occupations	2010	2011	2012	2013
	1	Total Full Time Equivalent (FTE) Employees (write-in)				
	2	Administrative, Management, and Legal Staff [as a % of a]				
	3	Engineers, Scientists, and R&D Staff [as a % of a]				
	4	Facility & Maintenance Staff [as a % of a]				
	5	Information Technology Professionals [as a % of a]				
	6	Marketing and Sales [as a % of a]				
	7	Production Line Workers [as a % of a]				
	8	Testing Operators, Quality Control, and Support Technicians				
	9	Other (specify)				
	10	Other (specify)				
	Lines 2 through 10 must total 100%		0%	0%	0%	0%
B	Estimate the percentage of your organization's Total FTEs that work on REE-related business lines [as a % of line A.1]:					

C	Does your organization currently have difficulty hiring or retaining employees?		
	If yes, indicate the primary reason(s) why you currently have difficulty hiring or retaining employees, particularly employees affiliated with your REE-related business lines. Explain each selection.		
		Primary Reason (select)	Explanation
	1		
	2		
	3		
	4		
	5		

D	1	Does your organization offer apprenticeship programs with academic institutions (e.g., community colleges, local trade schools, universities, etc.)? Explain your response.				
		Explanation:				
	2	Indicate the workforce development program preferred by your organization. Explain your selection.				
		Explanation:				
	3	Indicate if your organization participates in/sponsors any of the identified workforce development programs.	Apprenticeship		Internship	
			Certification		On-The-Job Training	
			Detail/Rotation		Reimbursement/ Subsidized	
			Fellowship		Specialized Coursework	
			Other (specify)			

E	Identify any unique skills and/or competencies that are essential to maintaining your organization's REE-related business lines. Explain each selection.		
		Type of Skill or Competency	Explanation
	1		
	2		
	3		
	4		
	5		

Comments:	

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Previous Page

Next Page

Section 11: Research and Development

Record your organization's total Research and Development (R&D) Expenditures and Funding Sources for the years 2010 to 2013.

Estimate the percentage of total R&D expenditures related to both your REE-related and Defense business lines.

Note: Ensure your "Source of R&D Data" declaration is consistent with your response in Section 1.a. This means that if you declared the survey response to be a Business Unit/Division-level response in Section 1.a then this section should contain Business Unit/Division-level data.

Note: R&D annual expenditure totals should match those your organization typically provides in its annual income statement.

	Source of R&D Data:				
	R&D Reporting Schedule:				
	R&D Expenditures	Record in $ Thousands, e.g. $12,000.00 = survey input of $12			
		2010	2011	2012	2013
A	Total R&D Expenditures (write-in)				
1	Basic Research [as a % of a]				
2	Applied Research [as a % of a]				
3	Product/Process Development [as a % of a]				
	Lines 1 through 3 must total 100%	0%	0%	0%	0%
4	Percent of Total R&D Expenditures relating to REE-related business lines				
5	Percent of Total R&D Expenditures relating to Defense business lines				
	R&D Funding Sources	Record in $ Thousands, e.g. $12,000.00 = survey input of $12			
		2010	2011	2012	2013
B	Total R&D Funding Sources (write-in)				
1	Internal/Self Funded/IRAD [as a % of B]				
2	Total Federal Government [as a % of B]				
3	Total State and Local Government [as a % of B]				
4	Universities--Public and Private [as a % of B]				
5	U.S. Industry, Venture Capital, Non-Profit [as a % of B]				
6	Non-U.S. investors [as a % of B]				
7	Other (specify)				
	Lines 1 through 7 must sum to 100%	0%	0%	0%	0%

	Compatibility and Constraints to REE-related R&D		
C	Does defense-related R&D shape the development of your commercial product lines?		
	If yes, estimate the degree of compatibility between your defense-related R&D and your commercial product lines, i.e., the percentage of your defense-related R&D, any given year, that supports your commercial business.		
D	Does the cost of REEs and/or related ores, compounds, material types, inhibit your ability to perform REE-related R&D?		
	Does limited availability of REEs and/or related ores, compounds, material types, inhibit your ability to perform REE-related R&D?		
	Do China quotas/trade restrictions inhibit your ability to perform REE-related R&D?		
	Have recent efforts to "design or engineer out" REEs from related product and application areas reduced or increased your incentive to invest in REE-related R&D?		
	REE-related R&D for Recycling/Substitution	Recycling	Substitution
E	Does your organization perform any R&D activities related to REE recycling and substitution?		
	If yes, estimate the proportion of your overall R&D expenditures related to REE recycling and substitution.		
	Does your organization plan on increasing future R&D activities related to REE recycling and substitution?		
F	Provide a brief description of your organization's R&D activities.		

Comments:	

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section 12: Capital Expenditures

Record your organization's capital expenditures corresponding to the select categories.

Note: Ensure your "Source of Capital Expenditure Data" declaration is consistent with your response in Section 1.a. This means that if you declared the survey response to be a Business Unit/Division-level response in Section 1.a then this section should contain Business Unit/Division-level data.

		Source of Capital Expenditure Data:				
		Capital Expenditure Reporting Schedule:				
		Capital Expenditure Category	Record in $ Thousands, e.g. $12,000.00 = survey input of $12			
			2010	2011	2012	2013*
A		Total Capital Expenditures				
	1	Machinery, Equipment, and Vehicles [as a % of A]				
	2	IT, Computers, Software [as a % of A]				
	3	Land, Buildings, and Leasehold Improvements [as a % of A]				
	4	Other (specify) [as a % of A]				
	5	Other (specify) [as a % of A]				
		Lines 1 through 5 must total 100%	0%	0%	0%	0%
	6	REE-related Capital Expenditures [as a % of A]				

B	Since 2010, have your organization's capital expenditures been adversely impacted by reductions in U.S. Government defense spending? Do you anticipate them to be impacted in the future? Explain your response.	
	Explanation:	

C

Barriers to entry or expansion in REE-related fields can be high, particularly in the early, capital-intensive steps of the REE value chain.

1. Describe any obstacles to the future procurement by your organization of new machinery, technology, and/or facilities necessary for expanding its REE-related business lines. Such investments might include the acquisition of equipment for the extraction, refinement, processing, manufacture, and/or recycling of REE-related material. Explain your response.

Availability		Interoperability		Operating Costs	
Environmental Regulations, Compliance		Lead Time		Purchase Price	
Expertise/Know-how		Licensing/Permits		Return On Investment	
Explanation:					

2. Does your organization own any of the following pieces of machinery and equipment?

If either yes or no, indicate the status of each machinery and equipment type. Explain your response.

Bioleaching Bacteria		Crushers		Flotation Separation Tanks/Jameson Cells	
Centrifugal Contractors		Electromagnets		Rock-breakers	
Chemicals used in Flotation Separation		Falcon/Gravity Concentrators		Saponification Equipment	
		Other (specify)			
Explanation:					

D

Identify and describe any unique or critical equipment, infrastructure, and/or facilities owned and/or operated by your organization in support of its REE-related business lines.

	Type of Equipment, Infrastructure, or Facility	Description (write-in)
1		
2		
3		
4		
5		

Comments:	

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section 13.a: U.S. Government Outreach

There are many federal and state government programs and services available to assist your organization to better compete in the global marketplace.

If you would like more information regarding these U.S. Government programs, select the specific areas of interest below.

The Commerce Department will follow-up with your organization regarding your selections.

A	Business development (joint ventures, new markets, etc.)		Patents and trademarks		
	Energy and environmentally conscious manufacturing		Product/service development (including manufacturing standards, processes, and practices)		
	Export licensing (ITAR/EAR)		R&D programs		
	Financing (access to capital, loans, etc.)		Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) contracts		
	Global export opportunities		Training Opportunities		
	Government procurement guidelines and e-commerce		Country Commercial Guides (specify most relevant country in box)		
	Manufacturing technology development (including acquiring, licensing, and/or commercializing federally developed technologies)		Other (specify)		
	Marketing assessment skills		Other (specify)		
	Comments:				

Previous Page Table of Contents

Section 13.b: Certification	
The undersigned certifies that the information herein supplied in response to this questionnaire is complete and correct to the best of his/her knowledge. It is a criminal offense to willfully make a false statement or representation to any department or agency of the United States Government as to any matter within its jurisdiction (18 U.S.C.A. 1001 (1984 & SUPP. 1197)).	
Organization Name:	
Organization's Internet Address:	
Name of Authorizing Official:	
Title of Authorizing Official:	
E-mail Address:	
Phone Number and Extension:	
Date Certified:	
In the box below, provide any additional comments or any other information you wish to include regarding this survey assessment.	
How many hours did it take to complete this survey?	

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

OFFICE OF TECHNOLOGY EVALUATION (OTE)
PUBLICATIONS LIST

October 2016

The U.S. Department of Commerce's Office of Technology Evaluation is the focal point within the Department for conducting assessments of defense-related industries and technologies. The studies are based on detailed industry-specific surveys used to collect information from U.S. companies and are conducted on behalf of the U.S. Congress, the military services, industry associations, or other interested parties.

PUBLICATION TITLE	*__Bold__ indicate forthcoming studies
U.S. Semiconductor Industry Assessment – Summer 2017	
Textiles, Apparel, and Footwear Industry Assessment – Spring 2017	
C-17 Aircraft Supplier Impact Assessment – Spring 2017	
U.S. Rocket Propulsion Industrial Base Assessment – Spring 2017	
Printed Circuit Boards Supply Chain Assessment– Fall 2016	
U.S. Strategic Material Supply Chain Assessment: Carbon Fiber Composites – Fall 2015	
Defense Industrial Base Assessment of the U.S. Underwater Acoustics Transducer Industry – Spring 2015	
Cost-Metric Assessment of Diminishing Manufacturing Sources and Material Shortages (Update) – February 2015	
U.S. Space Industrial Base "Deep Dive" Assessments: Small Businesses – December 2014	
U.S. Space Industrial Base "Deep Dive" Assessments: Workforce Issues – September 2014	
U.S. Space Industrial Base "Deep Dive" Assessments: Export Controls – February 2014	
Industrial Base Assessment of Consumers of U.S. Electro-Optical (EO) Satellite Imagery – August 2013	
National Security Assessment of the Cartridge and Propellant Actuated Device Industry: Fourth Review – July 2013	
Critical Technology Assessment: Night Vision Focal Plane Arrays, Sensors, and Cameras – October 2012	
National Aeronautics and Space Administration (NASA) Industrial Base – Post-Space Shuttle – June 2012	
Defense Industrial Base Assessment of the Telecommunications Industry Infrastructure – April 2012	
Reliance on Foreign Sourcing in the Healthcare and Public Health (HPH) Sector – December 2011	
Cost-Metric Assessment of Diminishing Manufacturing Sources and Material Shortages – August 2010	
Critical Technology Assessment: Impact of U.S. Export Controls on Green Technology Items – August 2010	
Technology Assessment of Fine Grain, High-Density Graphite – April 2010	
Defense Industrial Base Assessment of Counterfeit Electronics – January 2010	
Technology Assessment of 5-Axis Machine Tools – July 2009	
Defense Industrial Base Assessment of U.S. Integrated Circuit Design and Fabrication Capability – March 2009	

Archived Studies	
Defense Industrial Base Assessment of the U.S. Space Industry – August 2007	International Market for Computer Software with Encryption – NSA -1995
Technology Assessment of Certain Aromatic Polyimides – July 2007	The Effect of Imports of Crude Oil and Petroleum Products on the National Security – Dec. 1994
Defense Industrial Base Assessment of U.S. Imaging and Sensors Industry – October 2006	Critical Technology Assessment of U.S. Artificial Intelligence – Aug.1994
National Security Assessment of the Cartridge and Propellant Actuated Device Industry: Third Review – August 2006	Critical Technology Assessment of U.S. Superconductivity - April 1994
Economic Impact Assessment of the Air Force C-17 Program – Dec. 2005	Critical Technology Assessment of U.S. Optoelectronics – Feb.1994
National Security Assessment of the Munitions Power Sources Industry – Dec. 2004	Critical Technology Assessment of U.S. Advanced Ceramics – Dec.1993
National Security Assessment of the Air Delivery (Parachute) Industry – May 2004	Critical Technology Assessment of U.S. Advanced Composites – Dec. 1993
Industry Attitudes on Collaborating with DoD in R&D – Air Force – Jan. 2004	The Effect of Imports of Ceramic Semiconductor Packages on the National Security – Aug. 1993
Industrial Base/Economic Impact Assessment of Army Theater Support Vessel Procurement – Dec.2003	National Security Assessment of the U.S. Beryllium Industry - July 1993
A Survey of the Use of Biotechnology in U.S. Industry – Oct. 2003	National Security Assessment of the Antifriction Bearings Industry – Feb. 1993
Industrial Base Assessment of U.S. Textile and Apparel Industries – Sept. 2003	National Security Assessment of the U.S. Forging Industry – Dec. 1992
Technology Assessment of U.S. Assistive Technology Industry – Feb. 2003	The Effect of Imports of Gears & Gearing Products on the National Security – July 1992
Heavy Manufacturing Industries: Economic Impact and Productivity of Welding – Navy – June 2002	Natl. Sec. Assessment of the Dom. and For. Subcontractor Base~3 US Navy Systems - March 1992
The Effect of Imports of Iron Ore and Semi-Finished Steel on the National Security – Oct. 2001	Natl. Sec. Assessment of the U.S. Semiconductor Wafer Processing Equipment Industry - April 1991
National Security Assessment of the U.S. High-Performance Explosives & Components Sector –June 2001	National Security Assessment of the U.S. Robotics Industry - March 1991
National Security Assessment of the U.S. Shipbuilding and Repair Industry - May 2001	National Security Assessment of the U.S. Gear Industry – Jan. 1991
Statistical Handbook of the Ball and Roller Bearing Industry (Update) - June 2001	The Effect of Imports of Uranium on the National Security – Sept. 1989
National Security Assessment of the Cartridge and Propellant Actuated Device Industry: Update – Dec.2000	The Effect of Imports of Crude Oil and Refined Petroleum on Natl. Security – Jan. 1989
The Effect on the National Security of Imports of Crude Oil and Refined Petroleum Products – Nov. 1999	The Effect of Imports of Plastic Injection Molding Machines on Natl. Security – Jan. 1989
U.S. Commercial Technology Transfers to The People's Republic of China – Jan. 1999	The Effect of Imports of Anti-Friction Bearings on the Natl. Security - July 1988
Critical Technology Assessment of Optoelectronics – Oct. 1998	Investment Castings: A Natl. Security Assessment – Dec. 1987
National Security Assessment of the Emergency Aircraft Ejection Seat Sector – Nov. 1997	An Economic Assessment of the U.S. Industrial Fastener Industry – Mar. 1987
Critical Technology Assessment of the U.S. Semiconductor Materials Industry - April 1997	Joint Logistics Commanders/DOC Precision Optics Study - June 1987
National Security Assessment of the Cartridge and Propellant Actuated Device Industry – Oct.1995	Joint Logistics Commanders/DOC Bearing Study - June 1986

For further information about OTE's programs or for additional copies of reports, please visit us at
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