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14. ABSTRACT

Regardless of the rhetoric in the United States Congress about breaking its supply chain reliance on China, America still heavily depends on China to provide it with critical resources required for defense and everyday life. Rare Earth Elements (REE) are among the resources the US and the rest of the world rely on China to provide. Therefore, US leadership needs to invest more in diversifying its REE supply chain to reduce its dependency on China, minimizing the impacts of Chinese-driven disruptions in REE-reliant industries. First, the US needs to invest in domestic options to help reduce its dependence on Chinese REE products. Second, Vietnam and Brazil could provide opportunities for additional foreign options to supply the US and the world with these critical elements. Demand for REEs will only grow in the coming years and decades, making the diversification of the REE supply chain a vital interest for the US.

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The Hunt for Rare Earths: Breaking China's Hold on Rare Earth Elements

Regardless of the rhetoric in the United States Congress about breaking its supply chain reliance on China, America still heavily depends on China to provide it with critical resources required for defense and everyday life. Rare Earth Elements (REE) are among the resources the US and the rest of the world rely on China to provide. China is the largest importer and exporter, possesses the largest deposits and mines, and processes more REEs than any other country in the world. Without REEs, the US cannot truly lead the world in innovative technology, and transitioning to a greener economy would be impossible. Supply chain disruptions pose a significant risk to filling the demand for these critical elements, and with China solely dominating the REE industry, any disruption can be challenging. Therefore, US leadership needs to invest more in diversifying its REE supply chain to reduce its dependency on China, minimizing the impacts of Chinese-driven disruptions in REE-reliant industries. First, the US needs to invest in domestic options to help reduce its dependence on Chinese REE products. Second, Vietnam and Brazil could provide opportunities for additional foreign options to supply the US and the world with these critical elements.

What Is the Big Deal?

The definition of REEs can vary from source to source and market to market. The United States Geological Survey (USGS) identifies 15 REEs that range from lanthanum to lutetium on the periodic table. These REEs break down further into Light (LREE) and Heavy (HREE) Rare Earth Elements (Figure 1).[1] Understanding what REEs are is critical to conducting a practical

[1] Bradley S. Van Gosen, Philip L. Verplanck, Robert R. Seal II, Keith R. Long,and Joseph Gambogi, *Critical Mineral Resources of the United States—Economic and Environmental Geology and Prospects for Future Supply* (Virginia: U.S. Geographical Survey, 2017): 2.

analysis of the impacts tied to their restricted supply chains and how to improve the US's situation.

REEs are critical to US national interests and security because they are essential to producing advanced technologies and defense weapons systems. REEs are critical components of products that require catalysts (for use in oil refineries and automobiles), permanent magnets (for use in cell phones, wind turbines, and electric vehicle motors), fiber optics (for use in signal amplifiers and lasers), and lighting/displays (for use in fluorescent lights, cell phone screens, and computer displays).[2] For defense purposes, REEs are critical to radar, enhanced aluminum in fighter planes, and laser-guided weapons and precision-guided missiles. The modern F-35 aircraft contains 920 pounds of rare-earth materials.[3] Figure 2 gives a good representation of the impact and importance of REEs.[4] The US's reliance on REEs makes them a national security interest. The US must provide more options at home and within the international community to break its dependence on China for REEs.

Figure 1: REE Table

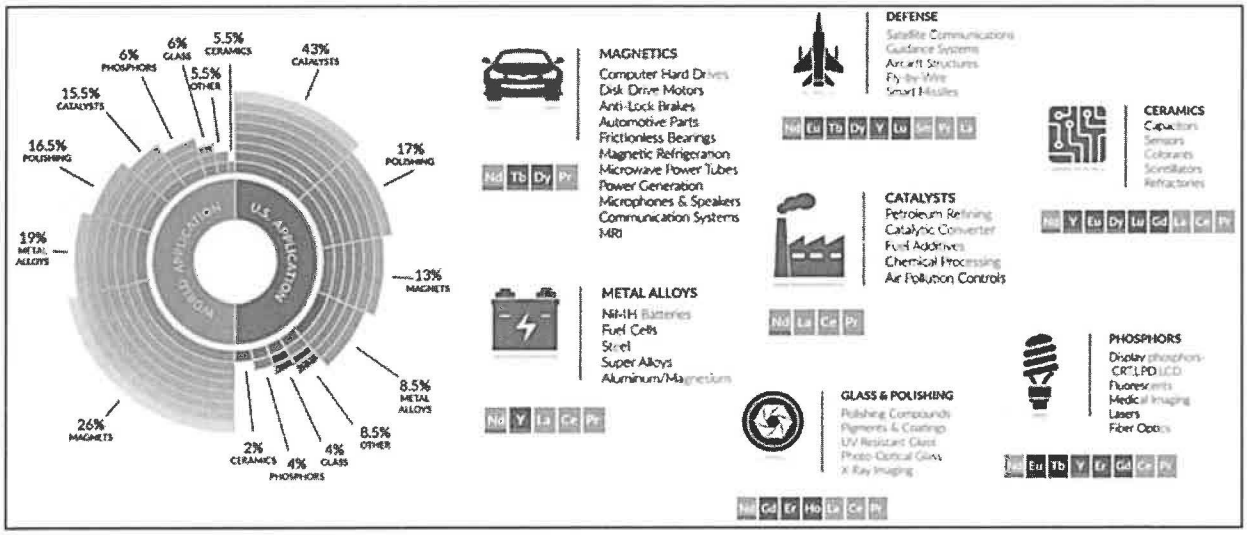
Element[1]	Symbol	Atomic number	Atomic weight	Crustal abundance (part per million)
Light REEs				
Lanthanum	La	57	138.91	39
Cerium	Ce	58	140.12	66.5
Praseodymium	Pr	59	140.91	9.2
Neodymium	Nd	60	144.24	41.5
Samarium	Sm	62	150.36	7.05
Europium	Eu	63	151.96	2.0
Gadolinium	Gd	64	157.25	6.2
Heavy REEs				
Yttrium	Y	39	88.91	33
Terbium	Tb	65	158.92	1.2
Dysprosium	Dy	66	162.50	5.2
Holmium	Ho	67	164.93	1.3
Erbium	Er	68	167.26	3.5
Thulium	Tm	69	168.93	0.52
Ytterbium	Yb	70	173.04	3.2
Lutetium	Lu	71	174.97	0.8

[1]Promethium (Pm, atomic number = 61) is not included in this list because it is extremely rare in nature.

Source: USGS *Critical Mineral Resources of the United States—Economic and Environmental Geology and Prospects for Future*

[2] Brandon Tracy, "An Overview of Rare Earth Elements and Related Issues for Congress " (Congressional Research Service, Washington D.C., 2020), 9.
[3] Brian Daigle and Samantha DeCarlo, "Rare Earths and the U.S. Electronics Sector: Supply Chain Developments and Trends" (U.S. International Trade Commission No. ID-21-075, Washington D.C., 2021), 26.
[4] Tracy, "An Overview of Rare Earth Elements," 9.

Figure 2: Critical REE Products and Industries



Source: National Energy Technology Laboratory (NETL), "REE-CM Program," https://www.netl.doe.gov/coal/rare-earth-elements/program-overview/background.

Currently, China dominates the REE mining and processing sector. China possesses the most prominent REE reserves on the earth at 44 million metric tons (mt), compared to the US's 1.8 million mt. Not only does China possesses the most significant known quantities, but also its mining and production rates far surpass those of any other country. USGS reports that China mined over 100,000 more mts of REE than any other nation in 2022.[5] China also dominates REE processing, which is the refinement of REEs into rare earth oxides necessary for end-item products.[6] These statistics show China's current monopoly over the REE industry. Unless the US seeks additional options to diversify its REE supply chain, China will continue to hold leverage over these resources. China could easily limit exports to others, driving demand and prices while fulfilling its domestic needs at discounted prices. With no other supplier options available, the rest of the world has to pay whatever cost for these critical resources.

[5] U.S. Geological Survey, Mineral Commodity Summaries, January 2022, 2.
[6] Daigle and Decarlo, "Rare Earths and the U.S. Electronics Sector," 11.

Expanding Options on the Homefront

The US should first increase REE production efforts at home to break Chinese dependency on its REE market. Two areas to address are mining and production capacities and capabilities. According to the USGS's latest import/export data regarding rare earth metals and alloys, in 2019, the US imported 77 percent of these products from China.[7] Demand for these materials will outpace their supply in the coming years.[8] The REE supply and demand issue is a US national security interest. Global events, such as COVID-19, can profoundly impact many industries tied to REE when disruptions in supply lines happen in a single provider system (China's current position). Efforts to provide these resources at home can go a long way to building resiliency in the US's REE supply chain.

The US government needs to set the conditions for REE companies to seek domestic solutions to the REE problem. Legislation introduced over the past few years regarding REEs involved tax breaks and expanded domestic REE productions, such as the REEShore Act (S.3530), the Rare Earth Element Advanced Coal Technologies Act (S.1052), Rare Earth Magnet Manufacturing Production Tax Credit Act (S.4680), and the ONSHORE Manufacturing Act (S.4033). However, these acts have yet to make it past their respective congressional committees and remained stalled.[9] Congress passed the CHIPS Act on the principle of over-reliance on foreign semiconductor production, similar to the REE situation. The bi-partisan passage of the CHIPS Act demonstrates Congress' appetite to address supply chain issues, like with REEs. The passage of these acts will help the US become more self-sufficient in the REE market.

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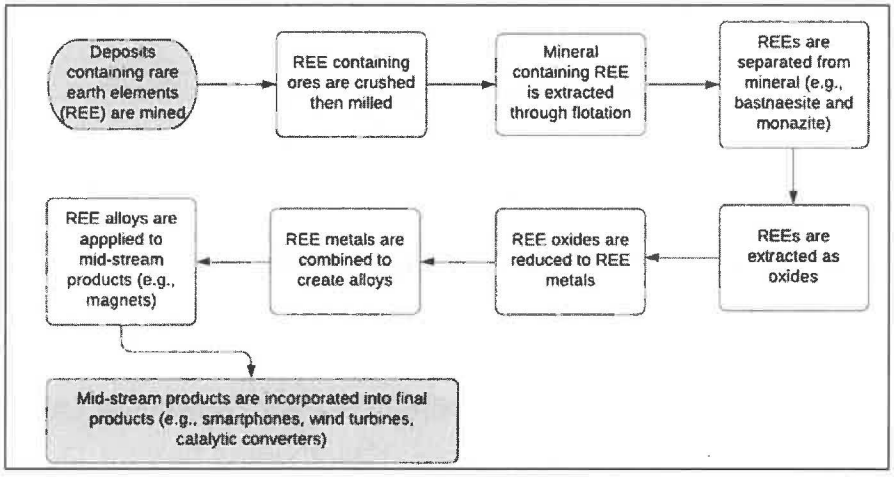
[7] "Rare Earths Statistics and Information," United States Geological Survey, accessed December 9, 2022, https://www.usgs.gov/centers/national-minerals-information-center/rare-earths-statistics-and-information.
[8] Marie Sophie Jaroni, Bernd Friedrich, and Peter Letmathe, "Economical Feasibility of Rare Earth Mining outside China" *Minerals* 9, 576 (2019): 3.
[9] "Congress.Gov," Library of Congress, accessed December 9, 2022, https://www.congress.gov/.

The US needs to expand its domestic REE mining capabilities to help alleviate dependency on imports. All domestic mining comes from the Mountain Pass Mine in California. Other identified locations have yet to start mining production.[10] Legislation can go a long way to help reduce administrative barriers required to get these mining productions online, including reducing the permitting process for new mining locations. The REE acts mentioned earlier deal more with REE processing, foreign restrictions, and reporting but does not address expanded mining capabilities. Mining domestically will be a critical piece to leveling the REE market.

Part of the issue with expanding REE efforts at home involves economic production challenges. Although named as such, REEs are not that rare within the Earth's crust, with some of these elements being more abundant than metals like copper or lead.[11] A study reviewing REE competitiveness suggests that contributing factors that determine economic feasibility for mining include: 1) quality of deposit; 2) infrastructure; 3) mining and processing margins; 4) waste disposal costs; 5) market prospects; and 6) political, economic, and logistic aspects.[12] Of these factors, mining and processing create the most significant fiscal challenges and require the most investment and

Figure 3: REE Production Overview



Source: Daigle and Decarlo, "Rare Earths and the U.S. Electronics Sector," 5.

[10] Tracy, "An Overview of Rare Earth Elements," 4-7.
[11] Gosen, Verplanck, Seal II, Long, and Gambogi, *Critical Mineral Resources of the United States*, 2-3.
[12] Gustavo A. Silva, Carlos O. Petter, Nelson R. Albuquerque, "Factors and competitiveness analysis in rare earth mining, new methodology: case study from Brazil", *Heliyon* 4 (2018): 8-9.

development to improve mining prospects.[13] Research and development into cost-effective extraction and processing must be part of legislation to strengthen domestic REE markets. The ONSHORE Manufacturing Act currently in Congress is an excellent start to investing in REE innovations. Research and development will also allow US investors to seek partnerships within other international markets that can help strengthen the US REE supply chain. Without improving REEs' mining and processing techniques, low projected profit margins could scare investors away, forcing the US and global partners to remain dependent on China for REEs.

International Opportunities

US leadership and private investors need to seek foreign investment options in addition to domestic efforts to diversify REE supply chains. International REE sources are important because the US's current REE deposits (1.8M mt) are small compared to other nations. Vietnam and Brazil, in particular, have a combined deposit amount (43M mt) almost equal to China's dominating deposits of 44M mt. However, Figure 4 shows both countries' limited mining efforts.[14] These statistics show these countries' high potential for alleviating the US reliance on Chinese resources. It is prudent to review each country's situation and where the US can invest to tap into these resources.

[13] Jianliang Wang, Meiyu Guo, Mingming Liu, Xinqiang Wei, "Long-Term Outlook for Global Rare Earth Production," *Resources Policy* 65, (2020): 7.
[14] U.S. Geological Survey, Mineral Commodity Summaries, January 2022, 2.

Figure 4: REE Mining and Deposits

	Mine production		Reserves[8]
	2020	2021[e]	
United States	39,000	43,000	1,800,000
Australia	21,000	22,000	[9]4,000,000
Brazil	600	500	21,000,000
Burma	31,000	26,000	NA
Burundi	300	100	NA
Canada	—	—	830,000
China	[10]140,000	[10]168,000	44,000,000
Greenland	—	—	1,500,000
India	2,900	2,900	6,900,000
Madagascar	2,800	3,200	NA
Russia	2,700	2,700	21,000,000
South Africa	—	—	790,000
Tanzania	—	—	890,000
Thailand	3,600	8,000	NA
Vietnam	700	400	22,000,000
Other countries	100	300	280,000
World total (rounded)	240,000	280,000	120,000,000

Source: U.S. Geological Survey, Mineral Commodity Summaries, 2. January

Vietnam

Other nations like Japan have identified Vietnam deposits as a viable alternative to Chinese REE. In 2010, China limited REE exports to Japan and the US, causing severe supply chain issues. Japan, in return, signed agreements with Vietnam to help shore up their future REE needs and started investing in Vietnamese mining and production.[15] By 2017, Vietnam became Japan's largest supplier of REE, breaking its reliance on China.[16] Regardless, Vietnam's mining efforts are small-scale and require additional investment to increase its capabilities and capacities to support a more extensive customer base.[17] Targeted US foreign assistance in economic

[15] Ichiko Fuyuno, "Japan and Vietnam Join Forces to Exploit Rare Earth Elements," Scientific American, accessed December 14, 2022, https://www.scientificamerican.com/article/japan-vietnam-join-forces-exploit-rare-earth-minerals/.

[16] Grace Hearty and Mayaz Alam, "Rare Earths: Next Element in the Trade War?," Center for Strategic and International Studies, accessed December 14, 2022, https://www.csis.org/analysis/rare-earths-next-element-trade-war.

[17] Nhu Thi Kim Dung, Pham Van Luan, Vu Thi Chinh , Tran Van Duoc, " An Overview of Rare Earth Ores Beneficiation in Vietnam," Journal of the Polish Mineral Engineering Society 1, No.2 (2021): 229.

development in REEs could expand Vietnam's mining capabilities and help it tap into its vast REE deposits.

Even with Japanese support, Vietnam's ability to process REEs remains limited. China remains Vietnam's largest importer of REEs due to the lack of internal processing.[18] Processing technologies in Vietnam are currently at the laboratory level and cannot process at the industrial capacity.[19] Vietnam primarily analyzes REEs composition rather than the industrial processing of REEs into REOs. US investments can target the processing capability gap in Vietnam's REE infrastructure to break China's dominance over Vietnam's exports. The US should pursue options to increase processing capabilities in Vietnam or to provide Vietnam with another choice to export materials to the US for processing. The legislation mentioned earlier would allow for the processing of Vietnam REE exports in the US. However, support for processing efforts in Vietnam requires additional legislation from Congress to incentivize investors.

One challenge with Vietnam is its troubled past with the US and that Vietnam is a communist country. Communist countries have human rights challenges that often limit US foreign aid. The US Department of State reports that Vietnam has human rights challenges, including rigged elections, oppressive police, restricted access to information, and equality issues.[20] However, the US regularly meets with the Vietnamese leadership to address human rights, with the last meeting executed on November 2, 2022.[21] The US currently provides over

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[18] "Rare-Earth Metal Compounds in Vietnam," The Observatory of Economic Complexity, accessed December 10, 2022, https://oec.world/en/profile/bilateral-product/rare-earth-metal-compounds/reporter/vnm?redirect=true#:~:text=THE%20FASTEST%20GROWING%20Rare-Earth%20Metal%20Compounds%20EXPORT%20MARKETS,2%20Japan%20%243.91M%20%28151%25%29%203%20Spain%20%24151k%20%2855.9%25%29.

[19] Dung, Luan, Chinh, and Duoc "An Overview of Rare Earth Ores," 229.

[20] "2021 Country Reports on Human Rights Practices: Vietnam," Department of State, accessed December 14, 2022, https://www.state.gov/reports/2021-country-reports-on-human-rights-practices/vietnam/.

[21] "2022 U.S.-Vietnam Human Rights Dialogue," Department of State, accessed December 14, 2022, https://www.state.gov/2022-u-s-vietnam-human-rights-dialogue/.

$260 million in foreign assistance to Vietnam, with a majority allocated to peace and security and economic development.[22] The continued talks between the US and Vietnam regarding human rights are encouraging. Continued dialogue opens up an opportunity for additional assistance in the REE realm. Should Vietnam continue to improve human rights, US investments in REEs could be very economically advantageous. Additionally, considering the scar tissue of the Vietnam War is essential when approaching a trade agreement. Viewing these US-Vietnam diplomatic efforts as a partnership rather than devolving to the imperialist perception of another western nation taking advantage of a developing country's resources is essential. Ensuring the Vietnamese feel like they have a seat at the table will help strengthen relations.

Today, Vietnam has vastly under-exploited its REE deposits. Reporting in Vietnam has suggested that the high quantities of LREE further limit foreign investment because HREEs are in higher demand.[23] Most REE mining happens in the Northern part of Vietnam at the Dong Pao and Xe Nam Mines, which mainly produce bastnaesite. The main element extracted from bastnaesite is Cerium, which is an LREE.[24] Although minerals like xenotime and monazite (which contain HREEs) exist, the main mineral excavation is bastnaesite.[25] The US would have to invest in developing Vietnam's ability to produce a wider variety of REEs, including HREEs. Geological surveys would need to discover new economically viable deposits, and US investors or the Vietnamese Government would need to make significant economic investments to develop new sites at the industrial level. The larger the start-up bill becomes, the harder the sale will be to

[22] "Foreign Assistance Dashboard," Department of State, Accessed December 14, 2022, https://foreignassistance.gov/.
[23] Mai Thanh, "Vietnam's rare earth not attractive to industrial powers," Vietnam Net Global, accessed December 14, 2022, https://vietnamnet.vn/en/vietnams-rare-earth-not-attractive-to-industrial-powers-scientist-546866.html.
[24] Dung, Luan, Chinh, and Duoc "An Overview of Rare Earth Ores," 229-233.
[25] Rare Earth Element Mines, Deposits, and Occurrences, United States Geological Survey, accessed January 25, 2023, https://mrdata.usgs.gov/ree/map-us.html.

Vietnam and US Investors. Another option the US could pursue is partnering with another country like Brazil to fill the HREE gap.

Brazil

Brazil also has massive REE deposits the US can tap into to increase security within the REE market. Brazil currently possesses over 21 million mt of REE deposits but only mined 500 mts in 2021.[26] Unlike Vietnam, Brazil's REE mining and production have been steadily decreasing over the past five years, according to the USGS.[27] Why this is happening is only speculation at this point, but opportunities still exist within the REE market. The US could invest in research and development or build additional mining capabilities to increase capacity within Brazil.

The US cannot allow China to beat it to a trade agreement with Brazil for REEs. China has already signed a deal with Brazil for iron exports, which could easily lead to Chinese investments in Brazil's REE deposits.[28] China has recently been interested in increasing its REE imports to offset slower production due to increased regulations at home against rising domestic and global demand.[29] The US may need to compete not only with Chinese REE production but also for REE foreign investments in places like Brazil and Vietnam. The US's window to act may be closing, making considerations to diversify the US's REE supply chain critical.

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[26] U.S. Geological Survey, Mineral Commodity Summaries, January 2022, 2.
[27] U.S. Geological Survey, Mineral Commodity Summaries, https://www.usgs.gov/centers/national-minerals-information-center/rare-earths-statistics-and-information.
[28] Ariel Cohen and James C. Grant, "America's Critical Strategic Vulnerability: Rare Earth Elements," Foreign Policy Research Institute, June 22, 2021, https://www.fpri.org/article/2021/06/americas-critical-strategic-vulnerability-rare-earth-elements/#:~:text=The%20primary%20example%20is%20Brazil%2C%20where%20China%E2%80%99s%20Ningbo,deal%20exemplifies%20the%20expansive%20nature%20of%20Chinese%20business.
[29] Pier Paolo Raimondi, "The Scramble for Africa's Rare Earths: China is not Alone," Italian Institute for International Political Studies, June 7, 2021, https://www.ispionline.it/en/publication/scramble-africas-rare-earths-china-not-alone-30725.

Brazil also presents an easier sell to American investment as its human rights history is vastly better than Vietnam's. Brazil still faces human rights challenges, including police brutality and government corruption. Unlike the communist regime in Vietnam, Brazil has a multiparty republic governed by a democratically elected government.[30] However, current assistance is only $88 million, primarily focused on humanitarian and health services.[31] The US has room to provide additional assistance to Brazil for economic purposes aimed at the REE market. Foreign aid investment in the REE sector would benefit the Brazilian economy and help strengthen US REE markets.

Geographic surveys in Brazil show that deposits present a diverse combination of LREE and HREE-producing minerals, making it a more desirable location than Vietnam. A survey of deposits in central Brazil has demonstrated that HREE-producing minerals are present along with LREE-producing minerals.[32] In a more extensive study of Brazilian soil, evidence suggests that HREE (although less abundant than LREEs) is minable in Brazil.[33] These studies show the potential to mine all kinds of LREEs and HREEs in Brazil. Investments in Brazil would alleviate the challenges Vietnam presented with HREEs. Having options across multiple nations provides flexibility for REE-reliant industries when specific markets restrict or reduce production.

Brazil's extensive mining industry has faced environmental challenges, causing concerns over expanding mining efforts to include REEs. According to the USGS, Brazil is the world's

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[30] "2021 Country Reports on Human Rights Practices: Brazil," Department of State, accessed December 14, 2022, https://www.state.gov/reports/2021-country-reports-on-human-rights-practices/brazil/.
[31] "Foreign Assistance Dashboard," Department of State, Accessed December 14, 2022, https://foreignassistance.gov/.
[32] N.O. Costa, N.F Botelho*, J. Garnier, "Concentration of rare earth elements in the Faixa Placha tin deposit, PedraBranca A-Type Granitic Massif, central Brazil, and its potential for ionadsorption-type REE-Y mineralization," *Ore Geology Review* 123, (2020): 15.
[33] Ygor Silva, Clístenes Nascimento, Yuri Silva, Caroline Biondi, and Cinthia Silva, "Rare Earth Element Concentrations in Brazilian Benchmark Soils," Soil Use and Management, 2016, https://www.scielo.br/j/rbcs/a/4V8Kj8L8xWbkcQDL5v4DD9r/?lang=en#.

second-largest producer of mineral ores and has many communities reliant on the mining industry. Brazil has recently had challenges with waste storage facilities and failing dams connected to mining operations. These failures have caused severe environmental issues in Brazil. Even with these catastrophic failures within the mining industry, the Brazilian government has not acted effectively to help prevent similar future situations.[34] REE mining brings the same requirements for waste storage and water access. US investments must consider the required infrastructure to make REE mining safe and profitable. These concerns lead to a strong argument against further expanded REE mining across the US and abroad.

Counter-Argument: Environmental Concerns

The Brazil case demonstrates a decisive argument against more REE mining which suggests environmental concerns pose too great an impact. The two methods most operations use to mine for REE produce toxic waste. For every ton of rare earth produced, the mining process yields 13kg of dust, 9,600-12,000 cubic meters of waste gas, 75 cubic meters of wastewater, and one ton of radioactive residue.[35] Maintaining and storing these REE byproducts is one of the cost challenges of efficiently mining for these elements. Local government regulations, as in Brazil, may also need more effective oversight to handle these wastes. Environmental protection requires significant infrastructure investments to support large-scale mining in Vietnam and Brazil.

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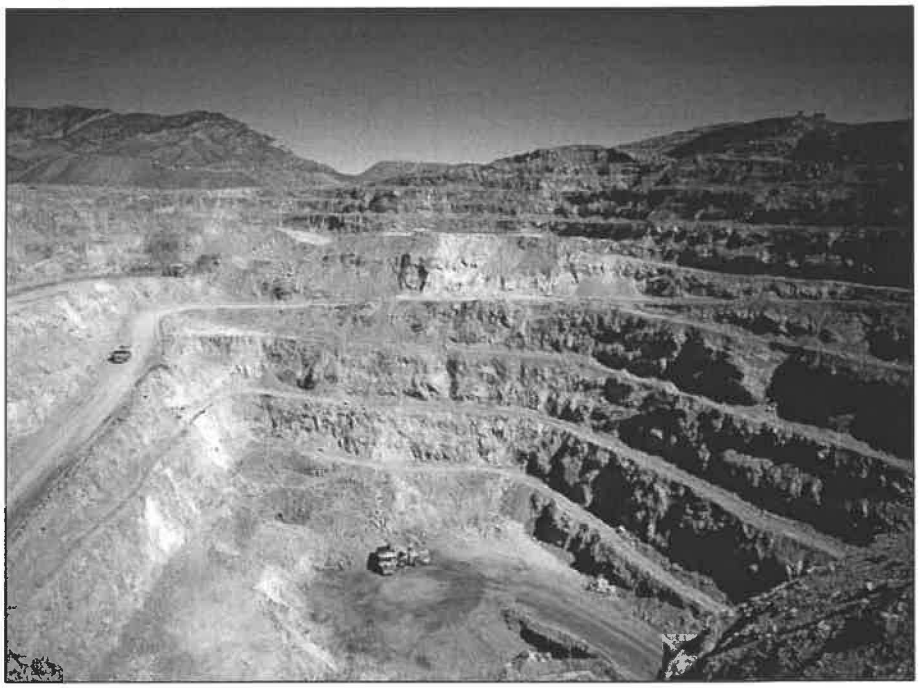
[34] Gilberto Salvador, Cecília Leal, Gabriel Brejão, Tiago Pessali, Carlos Alves, Gustavo Rosa, Raphael Ligeiro, Luciano Montag, "Mining Activity in Brazil and Negligence in Action," *Perspectives in Ecology and Conservation* 18, (2020), 137-142.

[35] Jaya Nayar, "Not So "Green" Technology: The Complicated Legacy of Rare Earth Mining," Harvard International Review, August 12, 2021, https://hir.harvard.edu/not-so-green-technology-the-complicated-legacy-of-rare-earth-mining/.

REE mining also presents occupational health risks. Human radiation exposure has been one of the most widely documented concerns related to past REE mining and processing activities. In 2005, Brazil faced challenges in dealing with a lack of radioactive protective equipment, resulting in investigations into health concerns.[36] The fact that REE mining and processing deals with radioactive materials makes the REE industry inherently hazardous. Significant investments in protective gear further exacerbate the costs of additional mining for these metals. These materials present risks to the workers at mines and processing centers, and poor storage can lead to environmental exposures that can reach the general population.

Figure 5: Mountain Pass, CA



Source: https://www.npr.org/2011/01/31/133372641/california-challenges-china-in-rare-earths-mining

China's environmental damage from years of aggressive REE mining has forced it to reconsider its mining practices and options, making US engagement in REE international markets more pressing. Poor lining in leeching ponds has resulted in toxic waste seeping into the

[36] Miranda Keith-Roach, Bertil Grundfelt, Anne Kousa, Esa Pohjolainen, and Paloma Magistrati, "Past Experience of Environmental, Health and Safety Issues in REE Mining and Processing Industries and an Evaluation of Related EU and International Standards and Regulations," EURARE project, 2015, 10.

Yellow River, a critical drinking water source in China.[37] Also, poor containment protocols for contaminated dust have resulted in offsite radioactive contamination leading to possible health issues.[38] These growing issues have led the Chinese to seek REE mining opportunities outside its borders in places like Africa.[39] China is simply offshoring its environmental burdens on other nations to maintain its REE monopoly. The US needs to pay more attention to ecological concerns regarding investments in developing countries, and make it harder to sell these opportunities to possible investors.

Environmentalists would offer increased recycling of REE from existing products to help US supply chain concerns. Researchers conducted studies to determine environmentally safe ways to recycle REEs, discovering a technique called plasma separation that provides a safe way to extract REEs from used electronics for repurposing efforts.[40] There is also much room to expand recycling efforts because REE recycling only involves around one percent of electronic waste.[41] A recent study reported that REEs from U.S. HDDs alone could meet 5.2 percent of global (excluding China) permanent magnets demand. For permanent magnets, recycling efforts could either reuse the magnets themselves or extract the REE from them for other uses.[42] The evidence shows the potential to use recycled REEs to feed market demands. Plasma separation in REE recyclables is environmentally safe and provides an alternative to taxing mining operations.

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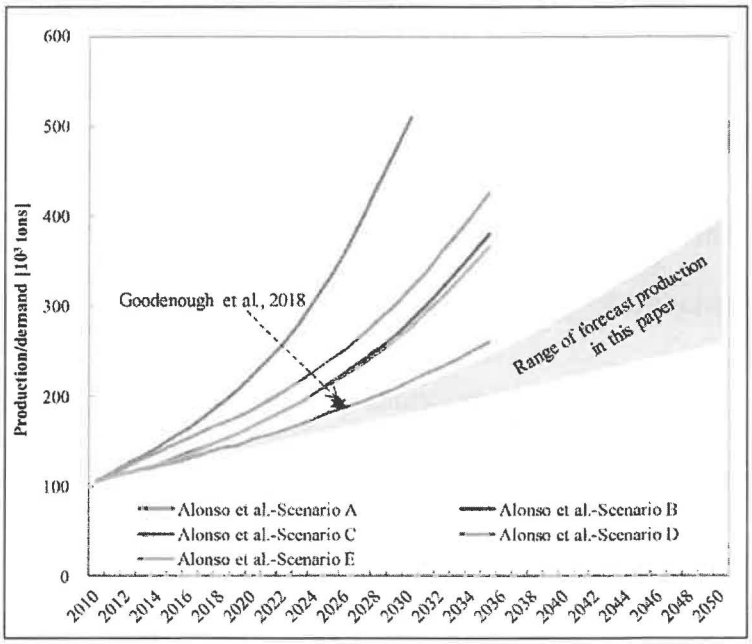
[37] Nayar, "Not So "Green", https://hir.harvard.edu/not-so-green-technology-the-complicated-legacy-of-rare-earth-mining/.
[38] Keith-Roach, Grundfelt, Kousa, Pohjolainen, and Magistrati, "Past Experience of Environmental, Health," 10.
[39] "How Rare-Earth Mining Has Devastated China's Environment," Earth.org, July 14, 2020, https://earth.org/rare-earth-mining-has-devastated-chinas-environment/.
[40] Renaud Gueroult, Jean-Marcel Rax, and Nathaniel J. Fisch, "Opportunities for Plasma Separation Techniques in Rare Earth Elements Recycling," *Journal of Cleaner Production* 182, (2016): 23-24.
[41] Nayar, "Not So "Green" , https://hir.harvard.edu/not-so-green-technology-the-complicated-legacy-of-rare-earth-mining/.
[42] I.C. Nlebedim and A.H. King, "Addressing Criticality in Rare Earth Elements via Permanent Magnets Recycling," *Journal of Minerals*, 70, No. 2, (2018): 115-118.

Exponentially Growing Demand

However, relying on recycling REEs alone will not be enough to meet the projected global demands for REEs. As the world moves towards clean, renewable energy, REEs will grow in demand due to their critical uses within clean energy technology, such as electric vehicles (EV). A study on EVs suggests that the need for these products alone will cause a strain on global REE supply.[43] A broader study suggests that demand will continue to outpace supply for REEs in the near and long term (Figure 6 shows potential trends in REE supply and demand projections).[44] Growing markets will require nations to seek more and more options to meet their REE requirements.

Figure 6: REE Demand Projection Model



Source: Jianliang Wang, Meiyu Guo, Mingming Liu, and Xinqiang Wei, "Long-Term Outlook for Global Rare Earth Production," Resources Policy 65, (2020): 6.

It is also challenging to make recycling efforts efficient with current processes. Recycling currently only extracts small amounts of REEs that can be repurposed. Recycling REEs only

[43] Xiang-Yang Li, Jian-Ping Ge, Wei-Qiang Chen, and Peng Wang, "Scenarios of Rare Earth Elements Demand Driven by Automotive Electrification in China: 2018–2030," *Resources, Conservation, and Recycling* 145, (2019): 327.

[44] Jianliang Wang, Meiyu Guo, Mingming Liu, and Xinqiang Wei, "Long-Term Outlook for Global Rare Earth Production," *Resources Policy* 65, (2020): 4-6.

happens in small quantities because of low yield and cost.[45] These challenges make reliance on recycling to meet REE demands unlikely. Although future innovations could yield better results in recycling, it is more prudent for the US to seek expanded mining options to meet its demand. Finding more ways to improve recycling is helpful, but at this time, recycling can only supplement the REE supply chain.

Recommendations

The US has options when it comes to diversifying its REE supply chain. First, the US could enter trade agreements with Vietnam and Brazil to enhance their mining efforts. An agreement could look similar to the Chip 4 Alliance proposal to secure semiconductor supply chains.[46] Australia is already partnering with Vietnam on resource production to include REEs.[47] China is already seeking economic opportunities in Brazil for other resources causing a potential time crunch for US action on the REE issue. The US could use the framework of the Australia-Vietnam agreement to include the US and Brazil.

Second, the US Congress must pass legislation addressing REE supply and demand issues. These acts should include tax incentives for domestic and foreign REE mining and production efforts. Currently introduced measures in Congress can help enhance US domestic efforts, but the creation of new legislation should aim to incentivize foreign investments outside China. Breaking China's monopoly over these resources does not mean the US needs to produce all of its requirements at home. In addition to domestic efforts, leveraging international partners

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[45] V. Balaram, "Rare Earth Elements: A Review of Applications, Occurrence, Exploration, Analysis, Recycling, and Environmental Impact," *Geoscience Frontiers* 10, (2019): 1294.
[46] Tian He and Cuhk-Shenzhen, "Biden Looks to Techno-Alliances to Chip in on Semiconductors," July 28, 2021, https://www.eastasiaforum.org/2021/07/28/biden-looks-to-techno-alliances-to-chip-in-on-semiconductors/.
[47] Nicholas Basan, "An Australia-Vietnam Partnership Could Erode China's Monopoly on Rare Earths," The Diplomat, November 21, 2022, https://thediplomat.com/2022/11/an-australia-vietnam-partnership-could-erode-chinas-monopoly-on-rare-earths/.

to help secure global supply chains will help improve the REE options worldwide. Effective legislation could incentivize private US companies to expand REE efforts at home and abroad.

Finally, legislation should include significant research and development funding to support and improve the REE Industry. It is critical to discover new ways to extract these metals more efficiently. Profit margin challenges remain the most significant barriers to expanded mining efforts. Advancements in REE mining and processing can help companies learn new and effective ways to increase those margins. Innovations could also reduce the environmental impacts of mining and improve the recycling efforts of REE. The world is looking towards transitioning to clean energy, and REEs are a part of that. The US could lead the world in innovative ways to produce these materials cleaner and more efficiently.

Conclusion

It is in the US's best interests to act quickly and diversify its REE supply chain. The supply chain issues in 2010 and 2020 demonstrate the challenges of relying on a single nation (China) to supply such critical resources. Until the discovery of REE substitutes for our cell phones, medical, and defense technologies, these metals remain a national security interest for the US. Pending efforts to improve the REE situation, the US and the world will remain at the mercy of China to feed their needs.

Enacting the U.S. Cyber Force:

The Key to Winning the Great Cyber Competition with China

INTRODUCTION

The enactment of a U.S. Cyber Force (USCF) combined with increased integration of Artificial Intelligence (A.I.) and automation will help win the great cyber competition with China. The 2022 National Security Strategy (NSS) highlights the President's desire to enhance cybersecurity partnerships and stresses the importance of out-competing China by improving U.S. cyber resilience. The U.S. must enact the USCF as the final service branch to remain competitive in the cyber fight. This thesis will be proven by expounding on China's cyber dominance, using the U.S. Space Force (USSF) as a model, highlighting the positive impact on talent management, and demonstrating the USCF is instrumental in helping counter China's cyber superiority. Senior leaders challenged with "strengthening norms that mitigate cyber threats and enhance stability in cyberspace" should take heed.[1]

China's cyber forces are becoming superior to U.S. cyber forces, and "many experts view China as the greatest cyber threat on Earth (Duke, 2020)."[2] Unfortunately, today's U.S. cyber posture cannot stay ahead of this pacing threat. Most cyber professionals have concluded that the U.S. is "either just as vulnerable to cyberattacks or even more vulnerable today than it was five years ago."[3] In fact, 81% of experts believe the U.S. cyber security posture has been on a steady decline for more than half a decade (figure 1).

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[1] National Security Strategy, Washington, D.C.: *Office of Homeland Security, (October 12, 2022),* https://www.whitehouse.gov/wp-content/uploads/2022/10/Biden-Harris-Administrations-National-Security-Strategy-10.2022.pdf

[2] Klevering, Griffin, "A Brief Look at Chinese Cyberwarfare", *Small Wars Journal* (January 26, 2022), https://smallwarsjournal.com/jrnl/art/brief-look-chinese-cyberwarfare

[3] Marks, Joseph and Schaffer, Aaron, "The U.S. Isn't Getting Ahead of the Cyber Threat, Experts Say", The Cybersecurity 202 (January 6, 2022), https://www.washingtonpost.com/politics/2022/06/06/us-isnt-getting-ahead-cyber-threat-experts-say/

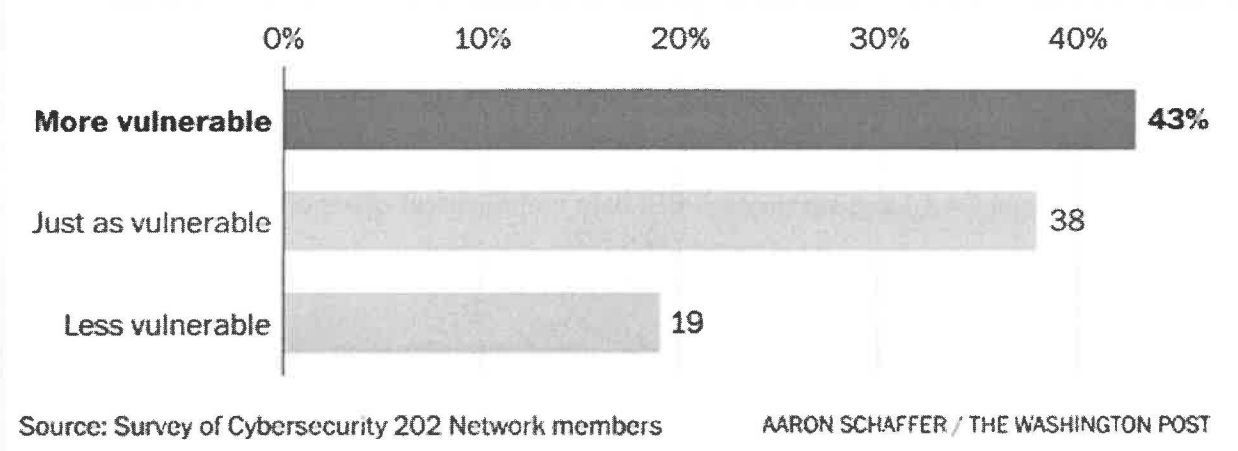

Figure 1. Is the U.S. more vulnerable, less vulnerable, or just as vulnerable to cyberattacks now as it was five years ago?

China initiates daily cyberattacks to exploit U.S. vulnerabilities, and the "NSA, CISA, and FBI continue to assess [People's Republic of China] PRC state-sponsored cyber activities as being one of the largest and most dynamic threats to U.S. government and civilian networks."[4] For example, "Atlassian" is a top Common Vulnerability and Exposure (CVE) used by the PRC that could enable China to execute malicious code on U.S. servers.[5] Attacks against the U.S. present a global danger to national peace and security, and if left unchecked, "cyber warfare as planned by the Chinese can take the nation down."[6] China's global threat was illustrated when the U.K. accused Chinese hackers of attacking many U.K. businesses. China has also struck Taiwan with cyber espionage.[7] Additionally, border disputes are increasingly becoming a point of contention in the quest for global dominance. Furthermore, China has used cyberwarfare as a

[4] "Top CVEs Actively Exploited by People's Republic of China State-Sponsored Cyber Actors", *Cybersecurity and Infrastructure Security Agency*, October 6, 2022, https://www.cisa.gov/uscert/ncas/alerts/aa22-279a

[5] "Top CVEs Actively Exploited by People's Republic of China State-Sponsored Cyber Actors", *Cybersecurity and Infrastructure Security Agency*, October 6, 2022, https://www.cisa.gov/uscert/ncas/alerts/aa22-279a

[6] Kannan, Saikiran and Bhalla, Abhishek, "Inside China's cyber war room: How PLA is plotting global attacks", *India Today*, August, 6, 2020, https://www.indiatoday.in/world/story/inside-china-s-cyber-war-room-how-pla-is-plotting-global-attacks-1708292-2020-08-06

[7] Klevering, Griffin, "A Brief Look at Chinese Cyberwarfare", *Small Wars Journal* (January 26, 2022), https://smallwarsjournal.com/jrnl/art/brief-look-chinese-cyberwarfare

weapon of choice to intimidate its neighboring country, India. Intelligence suggests China has enacted a secret People's Liberation Army (PLA) to use cyber tactics to degrade India's information and defensive security.[8] The U.S. must reassess its cyber posture to protect against this form of irregular warfare.

The U.S. has also become increasingly vulnerable to cyberattacks due to a lack of dedicated cyber resources. China is becoming dominant in the Great Cyber Competition with its dedicated cyber force, and the U.S. cannot defeat China without diminishing the dichotomy of cyber presence. The 2022 National Defense Strategy (NDS) identified China as the pacing threat, and this adversary has dedicated substantial resources to prepare for cyber warfare. China's PLA is dedicated full-time to imposing cyber threats on neighboring countries to further its global dominance. During a time of limited resources and DoD funding, the U.S. cannot sustain global power when faced with cyber war. China currently outnumbers the U.S. active and reserve military by approximately 1.12M (figure 2).[9] This large population provides more opportunities for China to recruit and retain dedicated cyber personnel.

Top 10 Countries with the Highest Number of Active-Duty and Reserve Military Personnel (in members):

1. Vietnam: 5,482,000
2. South Korea: 3,699,000
3. China: 3,355,000
4. Russian Federation: 3,014,000
5. India: 2,610,550
6. United States: 2,233,050
7. North Korea: 1,880,000
8. Taiwan: 1,820,000
9. Brazil: 1,706,500
10. Pakistan: 1,204,000

Figure 2. Top 10 countries with the highest number of military members

[8] Kannan, Saikiran and Bhalla, Abhishek, "Inside China's cyber war room: How PLA is plotting global attacks"
[9] "Military size by country 2023," World Population Review, accessed January 2, 2023, https://worldpopulationreview.com/country-rankings/military-size-by-country

China's dedicated cyber army places the U.S. at a disadvantage regarding global dominance, and the U.S. must consolidate forces to counter China's cyber power. Once done, the U.S. can focus on interoperability within the Joint Information Environment (JIE) and utilize A.I. and automation to reduce the loss of human life, supplement military recruiting shortages and manning deficits, and capitalize on emerging military technologies. These actions will also enable the U.S. to increase its focus on A.I. and automation to supplement military manning deficiencies and reallocate existing personnel to help create the USCF as its sixth branch of service. A.I. can complement limited military personnel and fill cyber recruiting and training gaps. Therefore, the U.S. should integrate more A.I. into its military Operations Plans. Additionally, automation can help sustain military forces and justifies the need for the establishment of the USCF to have a full-time focus on the cyber domain to compete with China. This concept successfully established the USSF to focus on the space domain.

A DEDICATED FORCE

General George S. Patton famously said, "A good plan violently executed today is better than a perfect plan executed next week." This statement still holds today as the U.S. must initiate steps to enact the USCF as soon as possible. According to the Small Wars Journal, "Within the next 5-10 years, China could overtake the United States and become the most powerful cyber nation."[10] Since China has a dedicated cyber army, the U.S. needs a dedicated cyber force to combat the power of China's cyber supremacy. Just as China has effectively capitalized on its PLA's massive workforce of well-trained cyber warriors, the U.S. must also

[10] Klevering, Griffin, "A Brief Look at Chinese Cyberwarfare", *Small Wars Journal* (January 26, 2022), https://smallwarsjournal.com/jrnl/art/brief-look-chinese-cyberwarfare

dedicate troops to protect the world against China and other bad cyber actors. This can be accomplished by modeling the establishment of the USSF, created to institute dominance in the space domain. According to USSF history, the space domain was identified as a national security imperative determined by "the growing threat posed by near-peer competitors in space, [and] it became clear there was a need for a military service focused solely on pursuing superiority in the space domain."[11] Similarly, the cyber domain impacts every aspect of warfare and requires a dedicated service to conduct unceasing offensive and defensive cyber warfare. To capitalize on emerging military technologies and create interoperability within the JIE, the U.S. military needs to make a solitary service with the mission of creating a collaborative environment on a global scale.

As outlined in the NSS, "The United States has a vital interest in deterring aggression by PRC behavior below, and above the traditional threshold of conflict [and] we cannot afford to rely solely on conventional forces."[12] The way wars of the past were fought will not suffice in modern times. Stove-piped efforts in combat will exacerbate the U.S.'s loss of global power. According to the NSS, "Our National Defense Strategy relies on integrated deterrence: the seamless combination of capabilities to convince potential adversaries that the costs of their hostile activities outweigh their benefits."[13] To accomplish these goals, we must secure cyberspace, and "as an open society, the United States [must establish] a clear interest in strengthening norms that mitigate cyber threats and enhance stability in cyberspace."[14] The

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[11] United States Space Force History. Accessed January 4, 2023. https://www.spaceforce.mil/About-Us/About-Space-Force/History/#:~:text=The%20establishment%20of%20the%20USSF,superiority%20in%20the%20space%20domain.

[12] National Security Strategy, Washington, D.C.: *Office of Homeland Security, (October 12, 2022),* https://www.whitehouse.gov/wp-content/uploads/2022/10/Biden-Harris-Administrations-National-Security-Strategy-10.2022.pdf

[13] NSS

[14] NSS

cyberspace domain is rapidly evolving, and currently, China is using cyberspace to conduct coercive activities in what the NDS refers to as the gray zone.[15]

Also stated in the NDS, cyber and space domains empower the entire joint force, and increased resilience in each environment is necessary.[16] However, establishing the USSF only covers 50% of the resiliency strategy highlighted. In December 2022, steps were made toward protecting the remaining threat by establishing the Cyber National Mission Force (CNMF) as the DoD's newest subordinate unified command.[17] While this is a step in the right direction, a subordinate unified command embedded within U.S. Cyber Command only protects a portion of the cyber mission. Specifically, this organization primarily defends the Department of Defense Information Network (DoDIN) and focuses less on cyber-like irregular warfare.

The U.S. must continue the momentum to cover the remaining 50% of the national security imperative by enacting the USCF. Advances in non-nuclear capabilities, such as cyber, will produce complicated and volatile pathways for conflict where collective understandings and behavioral norms are not clearly defined.[18] Currently, the U.S. Cyber Command oversees regionalized Service cyberspace components: ARCYBER, AFCYBER, FLTCYBER, and MARFORCYBER. However, "much of the work of Cyber Command is performed by its Service cyberspace components."[19] Each entity works on important but separate ventures to combat

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[15] National Defense Strategy, Washington, D.C., *(2022),* https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.PDF

[16] NDS

[17] U.S. Cyber Command. Accessed January 4, 2023. https://www.cybercom.mil/Media/News/Article/3250075/the-evolution-of-cyber-newest-subordinate-unified-command-is-nations-joint-cybe/#.Y6EDPFyUDLg.linkedin

[18] NDS

[19] U.S. Cyber Command. Accessed January 4, 2023.

China and other adversaries. The evolution must continue to create unity of effort and eliminate confusion, and the current construct (figure 3) should be further evolved to create the USCF.[20]

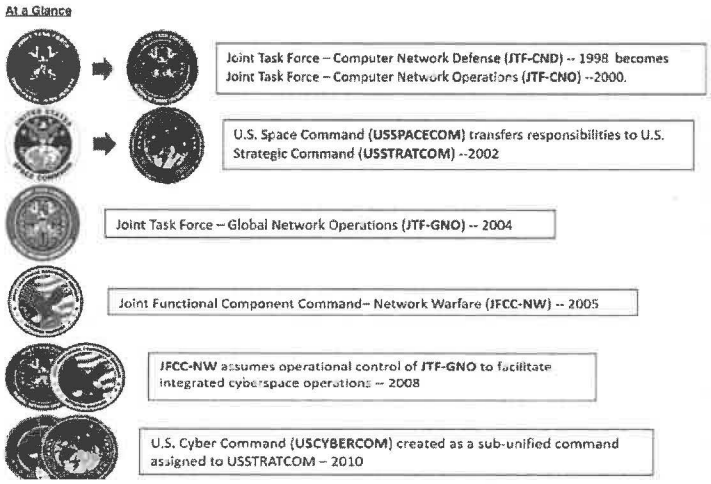

Figure 3: The evolution of the cyber organization.

A.I AND AUTOMATION/RECRUITING AND RETENTION

World War III (WWIII) is possible, with constant international vying for global dominance. However, unlike the previous two World Wars, the next one will not likely involve boots on the ground nor rely on ships on the seas. If WWIII is initiated, there will likely be a heavy cyber emphasis instigated by China to gain global dominance. Therefore, the Great Cyber Competition cannot be won solely with human assets. This will be the first unconventional global war, and the best way for the U.S. to win is through the enactment of the USCF. Creating the USCF will help establish interoperability of information technology and cyber systems where A.I. and automation will be the premise. To maximize combat power and extend operational reach, A.I. and automation employment must be amplified. Manpower resources are finite in the

[20] U.S. Cyber Command. Accessed January 4, 2023. https://www.cybercom.mil/About/History/#:~:text=Its%20mission%20is%20to%20direct,with%20domestic%20and%20international%20partners.

U.S. military. Therefore, emerging technologies are required to help reduce the loss of human life, supplement military recruiting shortages and manning deficits, and create interoperability within the JIE.

Technological innovation shows that "new applications of artificial intelligence, quantum science, autonomy, biotechnology, and space technologies have the potential not just to change kinetic conflict, but also to disrupt day-to-day U.S. supply chain and logistics operations."[21] The U.S. must lead the charge in implementing technological advancements by making suitable investments in technology and "be a fast-follower where market forces are driving the commercialization of militarily-relevant capabilities in trusted artificial intelligence and autonomy."[22] Modern warfighters rely on data-driven technologies and data integration that enhance intelligence efforts and provide prompt delivery to the warfighter.[23] Since the U.S. has a limited force size, "we [need to] aggressively seek to fill specific technology gaps, including in cyber, data, and artificial intelligence specializations, and work with colleges and universities to help build our future workforce."[24] This will be a crucial step toward cyber resilience.

Simultaneously, the U.S. must make a valiant effort to recruit and retain its cyber talent. The private sector has better technology, training programs, and resources. It is becoming more challenging to compete with the civilian cyber market. In fact, "troops who receive extensive cyber training, lured by the lucrative private sector, are parting ways with the military services

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[21] National Defense Strategy, Washington, D.C., *(2022),* https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.PDF

[22] NDS

[23] NDS

[24] NDS

quicker than some branches can offset the cost of that training."[25] The USSF is acquiring cyber troops from the USAF among the current service branches. Still, the USAF is adding three-year service obligations to retain its own cyber personnel. The U.S. Army is trying to double its cyber force, the U.S. Marine Corps (USMC) is not getting a good return on cyber training, and the U.S. Navy is trying to retain visibility on cyber billets.[26] The National Defense Authorization Act (NDAA) has pinpointed a lack of service obligation for cyber-trained personnel. This is a monumental problem since it could take up to three years and cost up to $500,000 to fully train a cyberwarrior, only to lose them to the private sector.[27] While the U.S. has already spent roughly $160 million to retain its cyber talent, it still lags behind countries like China. The best way to rectify this shortfall is to eliminate each service's separate recruiting and retention efforts and create a unified recruiting effort via the enactment of the USCF.

Continual steps must be made to attract cyber knowledge and retain the talent already acquired. For instance, the USAF recently released its Initial Enlistment Bonus (IEB) plan for 2023, offering up to $20,000 for six-year enlistments and a new "quick ship" program to foster faster recruitment efforts.[28] Additionally, physical fitness standards of the past are not conducive to attracting the cyber talent the U.S. military needs today. The world is not fighting the same conventional war fought previously. Cyber warriors don't need to run three miles nor complete a certain number of push-ups or sit-ups in an allotted time. The U.S. Army is the largest and oldest branch of service in the U.S., yet it still understands that old ways of thinking will cause demise

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[25] Lawrence, Drew. "Troops Are Getting Cyber Training and Then Rapidly Leaving the Military, Report Finds". *Military.com,* Accessed January 5, 2023. https://www-military-com.cdn.ampproject.org/c/s/www.military.com/daily-news/2022/12/27/troops-are-getting-cyber-training-and-then-rapidly-leaving-military-report-finds.html/amp

[26] Lawrence, Drew. "Troops Are Getting Cyber Training and Then Rapidly Leaving the Military"

[27] Lawrence, Drew. "Troops Are Getting Cyber Training and Then Rapidly Leaving the Military"

[28] U.S. Air Force Careers. Accessed January 8, 2023. https://www.airforce.com/careers/pay-and-benefits/enlistment-bonuses

in combat superiority.[29] Without unified guidance, the U.S. Army intends to initiate job-specific fitness scoring. This furthers the theory that a cyber soldier needs to be held to a different standard of physical fitness than a soldier in the infantry.[30]

Grooming standards also need to be reevaluated. The U.S. military requires the brainpower and cyber talent of those with beards, tattoos, piercings, pink hair, etc., that may be able to join the USCF in a military, civilian, or contractor capacity. These nuances are hindering cyber recruitment and retention across the joint force. The USMC is renowned for its high appearance and grooming standards; however, it still recognizes the need for change. The Force Design 2030 Annual Update highlights the desire "to change the recruit and replace paradigm, implement measures to professionalize career retention, and further incentivize retaining talented Marines."[31] The U.S. Navy strongly desires to work with joint partners to build cyber-secure information technology systems. The 2022 Navigation Plan (NAVPLAN) states, "We owe it to our people to create an ecosystem that recruits and retains diverse and technically skilled personnel, educates them to out-think our adversaries, and trains them to work with new technologies."[32] Winning the next major war also requires domestic cyber protection. Over $54 million of the U.S. Coast Guard's fiscal year 2023 budget has been allocated to cybersecurity and command, control, communications, computers, combat systems, and intelligence (C5I).[33] "The

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[29] U.S. Department of Defense. Accessed January 8, 2023. https://www.defense.gov/About/our-forces/#:~:text=The%20largest%20and%20oldest%20service,that%20protect%20the%20United%20States.

[30] Beynon, Steve, "The Army's Fitness Test Might Be Revamped Yet Again for Gender-Neutral and Job-Specific Standards", (December 7, 2022). https://www.military.com/daily-news/2022/12/07/armys-fitness-test-might-be-revamped-yet-again-gender-neutral-and-job-specific-standards.html

[31] Force Design 2030 Annual Update. Accessed January 8, 2023. https://www.marines.mil/Portals/1/Docs/Force_Design_2030_Annual_Update_May_2022.pdf (pg. 13).

[32] Chief of Naval Operations Navigation Plan 2022. Accessed January 8, 2023. https://media.defense.gov/2022/Jul/26/2003042389/-1/-1/1/NAVIGATION%20PLAN%202022_SIGNED.PDF (pg. 19, 22)

[33] "Taking the Helm: The Commandant's Vision for the U.S. Coast Guard", (July 14, 2022). https://www.congress.gov/117/chrg/CHRG-117hhrg49364/CHRG-117hhrg49364.pdf (pg. 11)

Coast Guard is committed to maritime border security, full participation in crisis response, and the protection of critical infrastructure, including in the cyber domain."[34] The U.S. cannot continue to allow individual services to maintain their missions while also trying to tackle a global cyber threat.

Additionally, the DoD cannot monetarily compete with the private sector and should focus on job satisfaction to help recruit and retain the necessary cyber talent. Every current branch of service is working independently to solve the problems with cyber talent recruitment and retention; however, these efforts need to be managed on a USCF scale versus being conducted through individual services. Single-service efforts assist with the short-term problem, but a sustainable solution should be the priority.

COUNTERARGUMENTS/RECOMMENDATIONS

Some may argue that creating an independent cyber force is too costly and unsustainable. Since the USSF was easier to develop from the USAF, it would be illogical to model that process for the USCF. "In a time of flat or declining Pentagon budgets, the notion that the department should create an entirely new service when interservice competition for resources is already fierce may seem an unaffordable luxury."[35] Each service will still have requirements for maintaining the existing command, control, communication, and computer (C4) systems. Each service still needs its cyber personnel to operate and maintain traditional information technology and communications requirements.

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[34] "Taking the Helm: The Commandant's Vision for the U.S. Coast Guard", (pg. 10)

[35] Barno, David and Bensahel Nora, War on the Rocks: "Why the United States Needs an Independent Cyber Force." (May 4, 2021). https://warontherocks.com/2021/05/why-the-united-states-needs-an-independent-cyber-force/

To accomplish this feat, the recommendation is to capitalize on a program recently adopted by the USAF called Enterprise I.T. as-a-service (EITaaS). "The EITaaS program is meant to outsource basic I.T. services so that the Air Force can free up airmen for more specialized, cyber-focused network defense and mission assurance."[36] EITaaS is being implemented in two waves. Wave one includes working with civilian industry to implement best practices into the government, and wave two involves overhauling antiquated base infrastructure. EITaaS will free up uniformed personnel to focus on military support, reduce costs, and limit risk by optimizing technology, people, processes, and data interaction.[37] Each service should follow suit and adopt a similar approach to maintain service-specific I.T. systems.

Some may also argue that U.S. Cyber Command is sufficient to combat global cyber threats, and a dedicated USCF would be a redundant effort. The individual services have repelled adversarial cyber threats and continue to do so with the overarching guidance of the U.S. Cyber Command. The CNMF's mission is to defend the U.S. by operating as a joint force "through full-spectrum operations, including offensive, defensive, and information operations."[38] This construct enables interoperability and promotes joint service collaboration to utilize the strengths of each branch.

However, individual service efforts have proven futile and cannot stay current with the nation's pacing threat. The overarching mission to protect and defend the domain should not be conducted in stovepipes. AFCYBER, ARCYBER, MARFORCYBER, FLTCYBER should all

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[36] Harper, Jon, Defense: "Air Force awards $5.7B contract for enterprise IT as a service". (August 31, 2022). https://www.fedscoop.com/air-force-awards-5-7b-contract-for-enterprise-it-as-a-service%ef%bf%bc/

[37] Peraton: "*Enterprise IT as a Service, Air & Space Force Mission Focus Starts with Enterprise IT.*" Accessed January 8, 2023. https://www.peraton.com/eitaas/

[38] U.S. Cyber Command. Accessed January 4, 2023. https://www.cybercom.mil/Media/News/Article/3250075/the-evolution-of-cyber-newest-subordinate-unified-command-is-nations-joint-cybe/#.Y6EDPFyUDLg.linkedin

be consolidated to form the USCF. For example, in April 2021, the USAF removed the words' Space' and "Cyber' from its mission statement. According to sources, the term space was removed due to the momentum made after the enactment of the USSF. The term cyber was initially added to the USAF mission statement in 2005 due to the increased threats to the U.S.'s network security but was still later removed.[39]

Nevertheless, removing the terms did not remove the threats. Threats to the space domain are more prevalent than ever, and the USSF has a firm grasp on combatting those threats. That leaves a persistent threat in the cyber domain. Just as a dedicated service branch was established to create and maintain space superiority, the USCF should be enacted to develop and maintain dominance in the cyber domain. The Air Force Chief of Staff initiated these changes, so the Air Force [could] now focus solely on Airpower and maintain a sustained focus on core air domain missions. Other service branches can also be relieved of global protection in the cyber domain, with the sole responsibility being shifted to the USCF.[40] Combatting threats from China is not a problem that can spread throughout individual services with service-specific missions. As per the U.S. Office of the Director of National Intelligence 2021 Annual Threat Assessment, "China presents a prolific and effective cyber-espionage threat, possesses substantial cyber-attack capabilities, presents a growing influence threat, and is conducting operations worldwide."[41]

Others may contend that A.I. and automation cannot resolve recruiting and retention issues since these options are poor substitutes for human intelligence. A.I. and automation lack

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[39] Pawlyk, Oriana, "Air Force Drops 'Space,' 'Cyber' from Mission Statement as Space Force Gains Momentum" (April 8, 2021), https://www.military.com/daily-news/2021/04/08/air-force-drops-space-cyber-mission-statement-space-force-gains-momentum.html

[40] Pawlyk, Oriana, "Air Force Drops 'Space,' 'Cyber' from Mission Statement as Space Force Gains Momentum" (April 8, 2021), https://www.military.com/daily-news/2021/04/08/air-force-drops-space-cyber-mission-statement-space-force-gains-momentum.html

[41] Cybersecurity & Infrastructure Security Agency. "China Cyber Threat Overview and Advisories", Accessed January 8, 2023. https://www.cisa.gov/uscert/china

the cognitive assessments required in combat, and this skill can only be found in humans. The military should reassess its recruiting and retention processes and focus less on technological advancements since A.I. is still in its infancy.

However, A.I. can compute faster and make judgments without emotion.[42] Discovering ways to streamline and effectively operate in the JIE with human assets has remained unresolved for over a decade. In fact, in 2013, the Chairman of the Joint Chiefs of Staff, Martin Dempsey, signed a whitepaper stating, "Globally integrated operations demands a far greater capacity to see, understand, operate in and defend cyberspace."[43] He later mentions, "JIE will allow better integration of information technologies, operations, and cyber security at a tempo that supports today's fast-paced operational conditions."[44] In modern warfighting areas, joint efforts are hindered by varying service branch goals, lack of collaboration, and limited resources. The responsibility to protect the entire cyber domain is too much to bear. Just as these sentiments were highlighted by the DoD Chief Information Office in 2016, the "DoD [still] stands at a crossroads facing a future I.T. environment that is fast-moving, connected, and highly contested."[45] The cyber threat that China poses spans beyond the traditional protection of hardware.

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[42] Eliacik, Eray. Dataconomy. "Artificial intelligence vs. Human Intelligence: Can a Game-changing Technology Play the Game?" (April 20, 2022). https://dataconomy.com/2022/04/is-artificial-intelligence-better-than-human-intelligence/#:~:text=making%20better%20judgments%3F-,Is%20Artificial%20Intelligence%20better%20than%20Human%20Intelligence%3F,go%20unnoticed%20by%20a%20person.

[43] Dempsey, Martin. Joint Information Environment Whitepaper. (January 22, 2013). https://www.jcs.mil/Portals/36/Documents/Doctrine/concepts/cjcs_wp_infoenviroment.pdf?ver=2017-12-28-162048-650

[44] Dempsey, Martin. Joint Information Environment Whitepaper. (January 22, 2013).

[45] Office of the Deputy DoD CIO for Information Enterprise. "*Additional Information about the Joint Information Environment (JIE)*". (July 2016). https://dodcio.defense.gov/Portals/0/Documents/JIE/Additional%20Info%20on%20the%20Joint%20Information%20Environment%20-%20DISTRO.pdf

The USCF would be responsible for protecting other aspects of the cyber domain, as highlighted by Frank Kendall, Secretary of the Air Force, "our personnel system, our medical system, our transportation system, our logistics system, [and] you have to think about all those things as well as all the weapons systems."[46] Kendall also expressed the importance of looking beyond traditional cyberattacks and focusing on disinformation's human influence.[47] These strengths, weaknesses, opportunities, and threats can be overcome and exploited with a consolidated USCF.

CONCLUSION

Cyber capabilities are the most potent weapons in the U.S.'s arsenal, and a dedicated force is needed to ensure they are appropriately utilized. The cyber domain impacts all other domains, and superiority in this domain will determine the winner of the Great Cyber Competition. Bad actors can use cyber to gain dominance in every instrument of national power: Diplomatic, Informational, Military, and Economic. The entity with the most cyber sovereignty can gain an advantage with diplomacy during negotiations. Disinformation can be used to alter the mind of citizens and damage civil infrastructure. Additionally, cyber can be used to infiltrate military communications and I.T. systems. A nation's economy can be jeopardized by damaging financial systems. "Often backed by adversaries, these cyberattacks threaten the United States and the rules-based order on which the global economy relies."[48] Whether overt or covert, the U.S. must take the necessary steps to reign supreme in cyber.

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[46] Gordon, Chris, Air and Space Forces Magazine: *"Disinformation, Data Collection are Cybersecurity Concerns, Kendall Says"* (December 4, 2022). https://www.airandspaceforces.com/disinformation-data-collection-are-cybersecurity-concerns-kendall-says/

[47] Gordon, Chris, Air and Space Forces Magazine: *"Disinformation, Data Collection are Cybersecurity Concerns, Kendall Says"* (December 4, 2022). https://www.airandspaceforces.com/disinformation-data-collection-are-cybersecurity-concerns-kendall-says/

[48] Securing Defense-Critical Supply Chains. *"An action plan developed in response to President Biden's Executive*

Supporting the President's goals to enhance cybersecurity partnerships, out-compete China, and improve U.S. cyber resilience will require innovation and strategic planning. Deterring PRC aggression will necessitate unconventional methods by unconventional means. "Therefore, cybersecurity standards and enforcement mechanisms that recognize shared national interests need to be developed."[49] Winning the Great Cyber Competition will require integrated deterrence and the combination of capabilities via the USCF to convince China that hostile activity threatening global security will be futile. Individual service efforts should be consolidated to remain dominant in the cyber domain. Bottomline, the U.S. needs to enact the USCF as the final service branch to win the Great Cyber Competition with China.

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[49] Securing Defense-Critical Supply Chains. *"An action plan developed in response to President Biden's Executive (pg. 54)*

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