From Mines to Missiles

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Introduction

Amid renewed calls for Europe to strengthen its defence capabilities, a long list of priorities emerges, from fighter jets and tanks to missiles, ammunition, electronic warfare, and radar systems. These assets share a common denominator: their production depends on rare earth elements (REEs). Like much of the world, Europe has grown increasingly dependent on China, which accounts for nearly 70% of global REEs mining and approximately 90% of global REEs processing capacity (Baskaran & Schwartz, 2025b; Mining Technology, 2025). This concentration is far from accidental

as China maintains export restrictions on REEs refining and processing technologies (Members' Research Service, 2025; Teer, 2025), effectively preventing competitors, including Europe, from replicating these capabilities and entrenching its long-term dominance across the supply chain.

To translate these constraints into policy choices, this article asks: **How can Europe strengthen its position in the field of rare-earth elements (REEs)?** It argues that no single solution can resolve Europe's REEs dependency in isolation. Instead, a layered approach combining onshoring, allied shoring, and nearshoring offers the most credible pathway towards greater resilience.

The article proceeds in six parts. It first clarifies how rare REEs are in practical terms. Second, it briefly describes the role of REEs in modern defence systems. Third, it traces the EU's evolving recognition of REE's strategic relevance and identifies key risk points in Europe's current supply model. Fourth, it assesses Europe's potential strategies for mitigating these risks: 1) onshoring, 2) allied shoring, and 3) nearshoring. Fifth, the article elaborates on potential mechanisms and bodies Europe could use to enact the identified strategies. The article concludes by outlining policy implications for building a more resilient European REEs framework.

How "Rare" Are Rare Earths?

Contrary to common belief, REEs are not scarce. Their perceived "rarity" stems instead from the difficulty and cost of extracting, separating, and refining them into usable metals (Kalantzakos, 2017c). REEs deposits are chemically complex, vary significantly by location, and require highly specialised, deposit-specific processing techniques (Andrews-Speed & Hove, 2023). Moreover, these processes are capital-intensive, technologically demanding, and environmentally hazardous, generating toxic waste streams and, in some cases, radioactive by-products (Filho, 2016; Kalantzakos, 2017b).

These characteristics explain why REEs processing is often economically unviable without sustained state support. Market prices alone rarely compensate for high upfront investment costs, regulatory burdens, and long development timelines. As a result, private actors face weak incentives to enter and remain in the sector. Policymakers therefore confront a structural dilemma: how to maintain domestic capacity for materials that are indispensable to national security, yet remain commercially unattractive under market conditions.

Rare Earths in Defence

The aforementioned challenges must be addressed if Europe is serious about building its own defence industrial base, of which REEs constitute a critical pillar. They are essential for advanced sensors, secure communications, precision-guided munitions, radar systems, permanent magnets,

and heat-resistant alloys (Girardi et al., 2023), among others. Yttrium, neodymium, and dysprosium, for example, are integral to electro-optical targeting systems, propulsion units, and navigation components used in fighter aircraft and armoured vehicles. According to the U.S. Department of Defence estimates, producing a single F-35 fighter aircraft requires approximately 417 kilograms of rare-earth materials (Grier, 2017). Figure 1 illustrates an exemplary use of REEs in an infantry fighting vehicle.

This functional centrality explains why REEs gradually moved from the margins of EU industrial policy to the core of strategic and defence planning.

Visualisation 1: Rare earth elements in an infantry fighting vehicle
[A reworked copy of https://hcss.nl/wp-content/uploads/2023/01/Strategic-Raw-Materials-for-Defence-HCSS-2023-V2.pdf]

Assessing Europe's Growing REEs Awareness and Its Current Risk Points

Over the past decade, Europe has gradually reframed its REEs narrative from predominantly economic into a more strategic one. Earlier policy frameworks, most notably the 2008 Raw Materials Initiative, approached critical materials primarily through industrial competitiveness, renewable energy, and technological innovation, with no explicit reference to defence or security considerations (European Commission, 2008).

This perspective has shifted markedly in recent years. The 2023 European Critical Raw Materials Act explicitly links secure access to REEs with the resilience of the European Defence Technological and Industrial Base, signalling that material dependency is no longer viewed as solely a trade vulnerability alone, but also a strategic security risk. This framing is reinforced by the ReArm Europe Plan (Readiness 2030), identifying critical raw materials as a prerequisite for sustained defence production and industrial scalability.

Despite this increased strategic awareness, Europe's vulnerability in REEs supply chains persists and is driven by four main risk factors (IEA, 2023). First, dependence on China remains overwhelming, particularly in midstream processing and separation, where Chinese firms dominate global capacity (Kalantzakos, 2017a). Beijing's export controls on REEs processing technologies further worsen this position by restricting the transfer of know-how and equipment necessary to replicate refining capabilities. As a consequence, even if ore is sourced elsewhere, it still tends to pass through Chinese-controlled refining, creating a structural bottleneck that diversification alone cannot fix.

Second, developing domestic REEs industrial capabilities is inherently time-consuming. Even under favourable conditions, the progression from geological exploration to commercial production typically spans a decade or more. Processing and separation facilities face similarly extended time-

lines, driven by technological complexity, high capital requirements, and the intensive use of financial, technical, and regulatory resources (Baskaran & Schwartz, 2025c).

Third, regulatory environmental policies within Europe significantly slow project development, raise costs, and deter private investment. Processing and separation are environmentally unfriendly and expensive (Han et al., 2025), while market prices are volatile and often insufficient to offset these high upfront costs.

Fourth, alternative suppliers remain limited. Even close partners such as the United States, Australia, and Japan face their own capacity constraints, processing bottlenecks, and growing domestic demand pressures. Consequently, expanding cooperation on REEs with other countries does not automatically eliminate vulnerability, as structural concentration and strategic inertia persist.

Strategies Forward: Onshoring, Nearshoring, and Allied Shoring

Having outlined the principal risks, this paper now turns to a discussion of potential pathways for addressing them, including onshoring, nearshoring, and allied shoring (Savoy, 2023). Applied to the European context, these categories help clarify feasible policy options in the context of existing geological, regulatory, and political constraints.

Onshoring refers to the development of domestic REEs capabilities across the value chain, encompassing extraction, processing, refining, recycling, and downstream manufacturing (Savoy, 2023). While full self-sufficiency is neither realistic nor necessary, onshoring remains indispensable for reducing Europe's exposure to strategic chokepoints, particularly in midstream processing and separation, where Chinese dominance is most acute.

In practice, Europe's potential for large-scale onshoring at the extraction stage is constrained by geological, environmental, and political factors. Although REEs deposits exist across several member states, their scale is modest and their exploitation often politically sensitive. The discovery of a potentially significant deposit near Kiruna in northern Sweden illustrates both the opportunities and the limitations of this approach (LKAB, 2025). While the find has generated optimism, geological assessments remain ongoing, permitting timelines are lengthy, and substantial infrastructure investment would be required before commercial extraction could begin. Even if fully developed, Kiruna would not materially offset Europe's overall import dependence.

Consequently, Europe's most realistic onshoring opportunities lie further downstream in the value chane, like processing, refining, recycling, and magnet manufacturing. Investment in midstream facilities would reduce Europe's exposure to processing bottlenecks, while the development of

recycling and reverse-logistics systems could gradually lower net import dependence (Kalantzakos, 2017a; McNulty et al., 2022).

Technological innovation can partially complement these efforts. Research into low-rare-earth or rare-earth-free permanent magnets seeks to reduce material intensity without sacrificing performance (Andrews-Speed & Hove, 2023). Similar trends are visible in the private sector, for example in the automotive industry (Ewing, 2025), where manufacturers increasingly aim to minimise REEs use in electric motors and power electronics. While such substitution cannot eliminate demand for REEs altogether, it can reduce pressure on the most constrained elements and enhance overall system resilience.

The economic dimension of onshoring remains the most binding constraint. Due to high capital intensity, environmental compliance costs, and exposure to volatile global prices, market forces alone are insufficient to sustain domestic REE capacity. As a result, policymakers increasingly rely on price-stabilisation mechanisms, long-term offtake agreements, and direct state involvement to de-risk investment. The United States has recently introduced price-floor mechanisms to support its domestic REEs producer and shield it from market volatility (Scheyder & Renshaw, 2025). In parallel, private actors have begun to anchor demand through long-term commitments: Apple, for example, has pledged approximately USD 500 million to support domestic REEs processing and recycling through offtake and investment agreements (Apple, 2025).

Taken together, these cases illustrate that effective onshoring requires a whole-of-chain and whole-of-government approach. Focusing narrowly on mining risks shifting dependency to other stages of the value chain. While onshoring will be time-consuming and costly, targeted investment in midstream processing, recycling, and downstream manufacturing can meaningfully reduce Europe's exposure to strategic chokepoints. Nevertheless, onshoring alone cannot resolve Europe's REEs challenge, underscoring the need for complementary allied shoring and nearshoring strategies.

Allied shoring involves securing access to REEs through politically viable partners. For Europe, allied shoring represents one of the most immediately available tools for reducing exposure to Chinese supply-chain leverage. Potential measures include joint stockpiling arrangements, shared processing and separation facilities, and coordinated investment frameworks with countries such as Australia, Brazil, South Africa, Japan, Vietnam (Baskaran & Schwartz, 2025b), and Canada (Hernandez-Roy, & Ziemer, 2025).

At present and for the foreseeable future, Australia stands out as the most consequential rare-earth supplier, beyond China and the United States. It possesses commercially viable deposits, a stable regulatory environment (Liu et al., 2023), and long-standing political alignment with Europe. Crucially, Australia has also invested in upstream and midstream capacity, including processing and separation. Australia is the largest producer of separated REEs outside of China, including its Lynas Rare Earths (Murphy

& Luck, 2025). However, Australia is still dependent on China, especially in oxides refining (Uren, 2023), which is expected to last at least until 2026 (Reuters, 2023). Furthermore, Australia develops its Browns Range to become the first significant dysprosium producer beyond China (Northern Minerals, 2025), but this endeavour still requires a lot of work (Baskaran & Schwartz, 2025b).

One of the dangers associated with the allied shoring is a potential risk of increasingly complex supply chains (Choi et al., 2005). In practice, however, this concern is overstated in the REEs context. The global supplier base outside China remains extremely limited, meaning that diversification does not involve managing a large number of alternative suppliers but rather reallocating volumes among a small and geographically concentrated set of producers (Kalantzakos, 2017a; Girardi et al., 2023).

The primary trade-off of this path are high costs as multi-sourcing undermines economies of scale and reduces access to the lowest-cost supplier, resulting in higher prices across the value chain (Andrews-Speed & Hove, 2023). Furthermore, without parallel investment in European processing, manufacturing, and recycling, allied shoring risks substituting one concentrated dependency with another, albeit among perhaps more friendly suppliers. Therefore, allied shoring can enhance resilience but cannot fully replace domestic or regional capability development.

Lastly, Nearshoring occupies the middle ground between homegrown capabilities and accessing REEs from elsewhere. Europe's neighbourhood, including Ukraine and parts of the Caspian region, holds potential for REEs extraction and processing (Bernard-Pearl, 2024). Developing these links could shorten supply chains and deepen strategic partnerships.

In practice, however, nearshoring faces substantial constraints. Many prospective partner regions are characterised by geopolitical volatility, unresolved security risks, and weak or uneven regulatory environments, all of which raise investment costs and complicate long-term planning. Moreover, while extraction potential exists, processing and refining infrastructure is often absent, meaning that nearshoring risks reproducing dependence on external midstream chokepoints without significant capital investment and technology transfer (Van Wieringen, 2025). Consequently, nearshoring extends beyond industrial policy alone and would require sustained European engagement in infrastructure development, capacity-building, and, in some cases, security assistance, which might also become politically sensitive.

As a result, nearshoring should be understood as a medium- to long-term strategy whose feasibility is contingent on broader regional stabilisation and the EU's willingness to assume a more active role in shaping its neighbourhood. When integrated with onshoring and allied shoring, nearshoring can contribute to diversification and resilience; pursued in isolation, however, it cannot deliver secure access to REEs.

AI generated. I couldn't generate a picture with appropriate arrows and text so I drew it myself properly. I put the AI-generated picture to visualize how I would like the map and flag symbols to look like.

From Strategy to Execution

Having discussed the potential pathways to Europe's enhanced REE resilience, one issue remains: How should these be enacted? An effective response requires a division of labour that leverages EU-level scale while preserving national implementation capacity.

Several core functions are best addressed collectively at the EU level. Market-shaping instruments, demand aggregation, and long-term risk absorption benefit from scale, credibility, and financial capacity that individual member states struggle to replicate. The European Union has already taken initial steps in this direction. The launch of the European Raw Materials Alliance (ERMA) in 2020 signalled a recognition that fragmented national approaches are insufficient to address structural dependencies in critical raw materials, particularly in magnets and motors (European Commission, 2025). Thanks to convening industry, academia, policymakers, and investors across the value chain, ERMA has a potential of a REEs coordination platform aimed at identifying investment bottlenecks, aligning industrial priorities, and mobilising capital for strategically relevant projects.

Japan's experience can offer a useful example that Europe could mirror. Following the 2010 rare earth supply shock, Tokyo adopted a coordinated strategy in which public institutions assumed responsibility for long-term planning and strategic risk absorption, while private actors executed commercial operations (Baskaran & Schwartz, 2025a). Through the Japan Oil, Gas and Metals National Corporation (JOGMEC), the Japanese state provided financing, took equity stakes in overseas projects, underwrote long-term offtake agreements, and established strategic stockpiles, all in close coordination with downstream industry. This approach significantly reduced Japan's dependence on Chinese supplies.

A comparable model could be adapted to the European context. At the EU level, institutions such as the European Commission, the European Investment Bank, the European Defence Agency, and PESCO could collectively assume responsibilities analogous to those fulfilled by JOGMEC, building on existing platforms such as ERMA. This would include demand signaling, coordinating long-term offtake agreements for defence- and energy-critical applications, managing joint stockpiles, and co-financing strategically relevant processing, magnet manufacturing, and recycling projects (Baskaran & Schwartz, 2025a). Such EU-level coordination would enhance scale and predictability while preventing duplication and fragmentation across member states.

At the same time, it is vital to recognise that member states remain indispensable for implementation. Permitting, environmental regulation, land-use decisions, and public acceptance fall firmly within national competence. National governments are also better positioned to engage directly with domestic industry, provide targeted subsidies, or take selective equity stakes through development banks or sovereign investment vehicles. Rather than centralising all responsibility in Brussels, Europe's challenge lies in aligning EU-level strategic coordination with national execution.

Policy Recommendations & Conclusion

Europe's vulnerabilities in the REEs supply chains are not a marginal industrial concern; they are a consequential structural constraint that directly undermines the realisation of its defence ambitions. As such, REEs are best understood as the "vitamins" of modern defence: they are required in small quantities, yet without them, advanced military systems cannot function.

No single policy instrument can fully eliminate Europe's REEs dependencies, which warrants a pragmatic and layered policy approach. Over the long term, Europe should prioritise the development of its own REEs capabilities wherever feasible, adopting a whole-of-chain strategy that extends beyond extraction and includes processing, refining, recycling, and downstream manufacturing (Baum, 2025). However, given geological constraints, regulatory hurdles, and high costs, such efforts are unlikely to deliver full self-sufficiency. On the other hand, such efforts could reduce vulnerabilities by mitigating the most acute chokepoints in the value chain and thus strengthen the European defence sector's resilience.

During the lengthy and politically constrained process of building domestic capacity, allied shoring offers the most immediately effective means of addressing urgent supply gaps. Over the short term, cooperation with politically reliable partners, most notably Australia, can enhance supply chain predictability and reduce dependencies on China, albeit at a higher cost. Additionally, nearshoring can accompany allied shoring, but its efficiency remains contingent on broader regional stabilisation, infrastructure development, and sustained EU external engagement, which generates further costs.

Crucially, implementing this policy alternatives requires a clear division of responsibility between the European Union and its member states. EU-level coordination, for example through platforms like ERMA, is indispensable for aggregating demand, shaping markets, and providing strategic scale through instruments such as joint purchasing, coordinated stockpiling, and investment frameworks. At the same time, member states remain central to implementation, particularly in permitting, environmental regulation, industrial support, and public acceptance.

Onshoring, allied shoring, and nearshoring, underpinned by suitable EU-level mechanisms, are best conceptualised not as rival strategies but as

complementary and mutually reinforcing tools. Complete independence from external suppliers is simply not realistic; what matters is ensuring reliable access to the "vitamins" of modern defence. To avoid perpetuating a dependency that undermines resilience, Europe must implement proactive investment frameworks, coordinated industrial policy, and strategic cooperation with trusted partners. Even if full REEs autonomy remains unattainable, Europe must nonetheless pursue it pragmatically, working within existing structural and resource constraints.

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