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Raw material and supply chain vulnerabilities in the Dutch defence sector

An analysis of the Air Defence & Command Frigate

Irina Patrahau and Benedetta Girardi in collaboration with PwC

October 2024

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This report was commissioned by the Netherlands Ministry of Economic Affairs. The conclusions and recommendations presented in this study are the result of independent research. Responsibility for the content rests with the authors and the authors alone.

HCSS and PwC jointly performed this research, combining their expertise to analyse the LCF supply chain and identify policy recommendations. HCSS' primary focus was on identifying supply chain vulnerabilities given geopolitical dependencies, PwC's primary focus was on the LCF supply chain analysis. Policy recommendations were validated with the Ministry of Economic Affairs and the Ministry of Defence.

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Executive Summary

Context and goal of the study

Global tensions have renewed the interest of the European Union (EU) and member states like the Netherlands to invest in modernizing their militaries and revitalizing domestic industrial capabilities. The rise of China and the shift of United States (US) strategic interest from Europe to the Indo-Pacific, Russia's military threat, and conflicts in the Middle East point to the need for European militaries to strengthen operational readiness and invest in the development of capabilities. At the same time, geopolitical tensions are putting pressure on trade relations, with implications for the supply security of strategic goods. Global supply chains have been strained ever since the COVID-19 pandemic and Russian invasion of Ukraine. These events have been wake-up calls for European leaders to reduce import dependencies in vital sectors like energy, healthcare, high-tech products. The escalating US-China tensions are bringing even more urgency to the EU to strengthen self-sufficiency in the military domain.

In this rapidly evolving geopolitical context, the Dutch Ministry of Economic Affairs commissioned The Hague Centre for Strategic Studies (HCSS) and PwC to conduct research into the supply chain vulnerabilities of a specific military platform. The objective of this study is (1) to identify and analyse geopolitical vulnerabilities along the supply chain of the respective military platform, with a specific focus on (critical) raw materials; and (2) provide policy recommendations for the Dutch government to build resilience and mitigate the risk of disruptions. This study is focused on the military-specific components and sub-components of the platform, particularly on weapons systems, sensors, command systems and electric technologies.

Platform of choice: the Air Defence & Command Frigate

This research focuses on the Air Defence & Command Frigate (Luchtverdedigings- en Commandofregat - LCF). The strong focus of the Dutch Defence Industrial Strategy on the maritime domain and the ease of access to information narrowed the search for suitable platforms to the maritime domain, specifically to surface vessels. The desire to look at supply chains of military-specific systems of the chosen platform resulted in the LCF as the case study. The LCF has both offensive and defensive capabilities with a variety of weapon systems, sensors, and communication equipment, and is a vessel with a relatively high share of Dutch designed/made systems on board.

Findings from the supply chain analysis

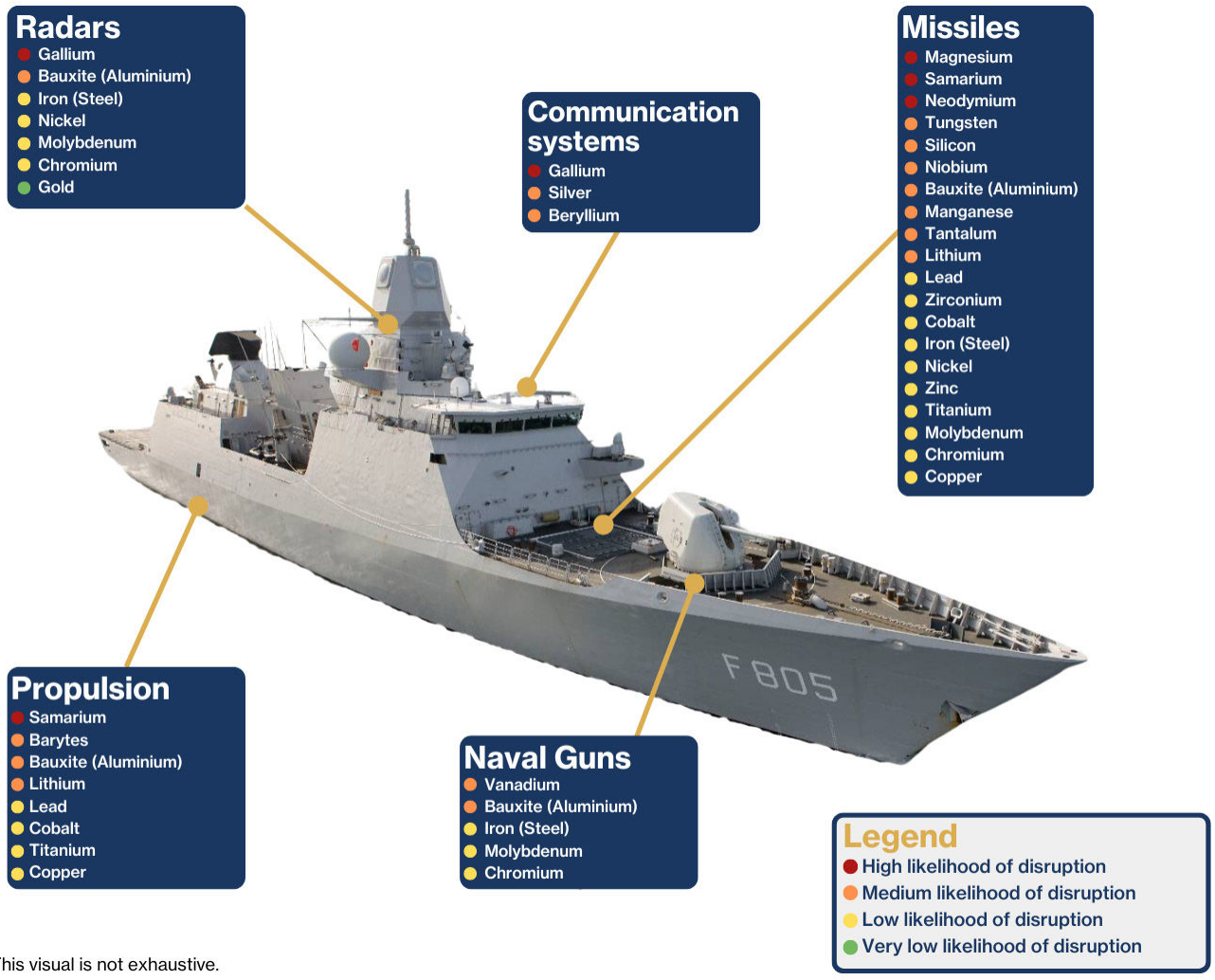
The research has shown that the MoD has a well-documented (tier-1) system breakdown of the LCF, enabling the identification of critical systems for the platform's functioning. All tier-1 suppliers (major system suppliers) are based in EU and North Atlantic Treaty Organization (NATO) countries.

Information about the supply chain beyond tier-1 is notably scarce. The MoD does not have access to more specific supply chain information. Moreover, industry interviews have not resulted in more detailed insight into the supply chain. Neither could information on raw material dependencies be provided. One of the major suppliers of systems indicated that detailed supply chain information was not available for the legacy systems but might be implemented in the future. Suppliers understand the risks of CRM dependencies, but their activity in mitigating these is limited, or could not be brought to light by this research.

Geopolitical dependencies and vulnerabilities

The defence industry has been less prominent in discussions about raw material dependencies than sectors like automotive and energy, but it could face price spikes or supply disruptions. The supply chains of 29 materials likely used in the LCF have been analysed. Out of these, 21 are on the EU's 2023 lists of critical and strategic materials. These materials are used in the components of military ships (radars, naval guns, etc.), but the information was collected from publicly available sources and not from LCF documentation. The results of the analysis are shown in Figure 1. A sizable group of critical raw materials (CRM) have already been affected by export legislation in China. For others, like magnesium, European industries encountered shortages because of disruptions in Chinese domestic production in 2021. Finally, most other analysed materials have not yet encountered disruptions, but the likelihood is relatively high due to, for example, the supply concentration, institutionally weak countries of origin with unstable relations between the Netherlands/EU, low recyclability, or substitution rates.

Figure 1. Raw materials in the Air Defence and Command Frigate (LCF)

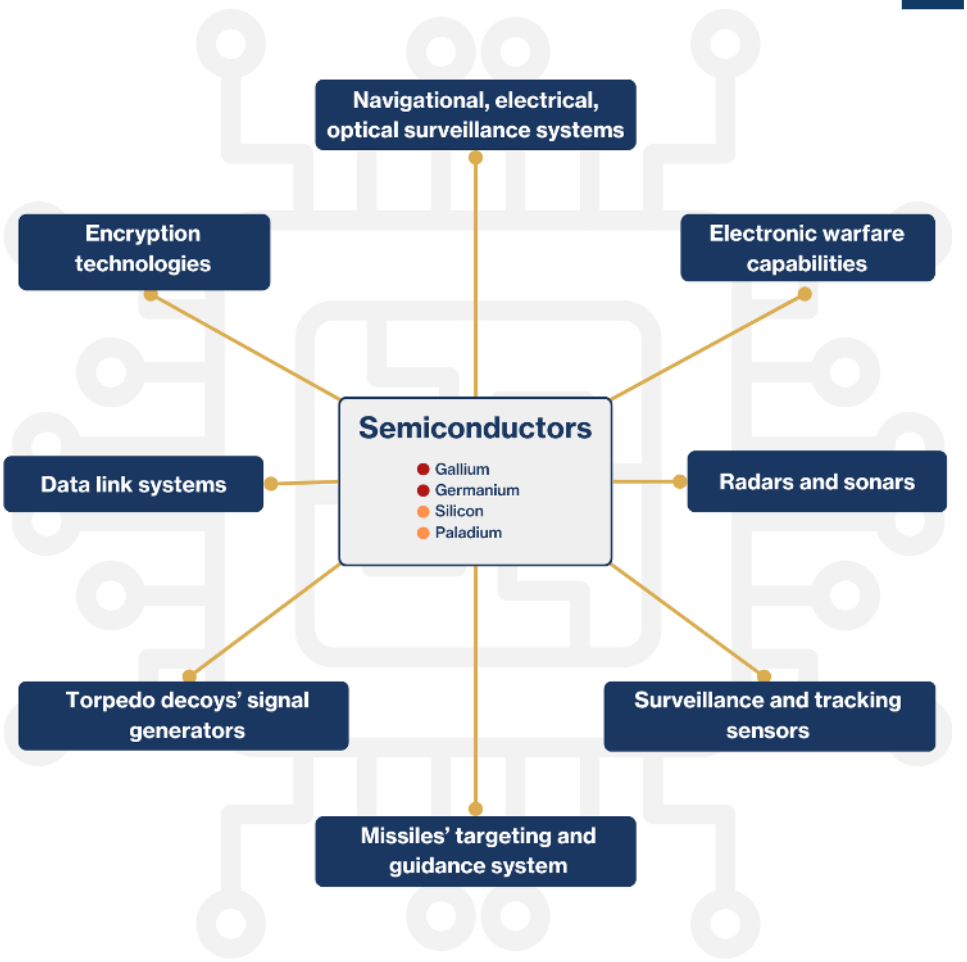


Note: This visual is not exhaustive.

Moreover, semiconductors are a crucial component for defence applications. They are fundamental to the operation of communication systems, radar, and electronic warfare equipment, enhancing the capabilities and effectiveness of defence operations. This makes the potential impact of a supply disruption very high. While the semiconductor value chain is concentrated in the US, Taiwan, Japan, South Korea and the Netherlands, the materials needed for manufacturing these chips originate in more unstable or politically unfriendly countries like China, Russia or the Democratic Republic of the Congo (DRC), increasing supply chain vulnerability.[1] Since semiconductors are used across vital sectors like digital, energy and health technologies, not just in defence, a disruption in their supply chain – whether in the supply of raw materials or product manufacturing – may have negative consequences across the European society as a whole.

1 In this report, we consider the materials that can be found across all types of chips (from legacy to advanced). These materials are gallium, germanium, silicon, and palladium. Other materials such as cobalt and rare earths have been excluded from this analysis either because they are used only in specific types of semiconductors (that we cannot be certain that they are found in the LCF) or because they are present in very low quantity and exclusively in alloys with other materials. For additional information of critical raw materials used in semiconductors, see: Joris Teer and Mattia Bertolini, 'Reaching Breaking Point: The Semiconductor and Critical Raw Material Ecosystem at a Time of Great Power Rivalry' (The Hague Centre for Strategic Studies, 19 October 2022).

Figure 2. Semiconductors in LCF components



Further down the supply chain, tier-1 suppliers for the LCF are based in EU and NATO countries. Still, evolving geopolitical and geo-economic conditions should be continuously monitored as they may impact the Dutch procurement of critical components. Finland's recent NATO membership and its extensive border with Russia could lead to an increase in demand for components, which may impact defence procurement in the rest of Europe in the short term, including the Netherlands. The upcoming US elections could influence Dutch-US relations, especially if there are significant political shifts. Amid increasing Sino-American competition and the Russian aggression on Ukraine, there is an increasing tendency towards protectionism. Monitoring the rise in protectionist policies and the possible impact on international procurement is crucial for ensuring the uninterrupted supply of critical components for the LCF.

Policy recommendations for the LCF

To address geopolitical vulnerabilities in the Dutch defence sector, specifically in the LCF, five high-level recommendations have been developed. These recommendations are based on findings from the supply chain analysis performed in this study and hold for the LCF in particular, where information is particularly scarce. These recommendations can support other military platforms as well, depending on specific needs. Of course platform specific dependencies might result in a different translation of these high-level recommendations into policy interventions (see below).

1. Enhance awareness, understanding and skills

Availability of information and insights into supply chain vulnerabilities are vital to implement effective policies. Thus, increasing awareness and understanding of defence supply chains should be a priority for Dutch policymakers and the defence industry. At the same time, dealing with supply chain dependencies requires a specific skill set, including scenario building and analysis, and stakeholder engagement and communication.

2. Integrate the defence industry in CRM-related activities

The Ministry of Defence and defence industry can reap benefits from broader policies and measures regarding supply chain resilience that are already being taken by/for larger industrial sectors in the Netherlands under the coordination of the Ministry of Economic Affairs. Dialogue on the needs of the Dutch defence industry is necessary to find a proper balance between the industry's needs and the government's possibilities. It can also support alignment with broader European initiatives where parts of the Dutch government are already involved. The Dutch Raw Materials Strategy is under implementation, and actions like integrating defence systems into this strategy can yield notable benefits. Where necessary, developing and implementing defence-specific roadmaps in the context of the National Resource Strategy can be explored further.

3. Improve response to supply chain disruptions

The Ministries of Economic Affairs and Defence should develop a roadmap with the industry, knowledge institutions and relevant governments to improve the resilience and sustainability of the LCF supply chain. This would allow policymakers and the defence industry to improve short-term response, for instance through stress-testing and optimizing inventories, but also take long-term action toward a circular and resilient supply chain. The roadmap could be integrated in the circular manufacturing industry programme of the Ministry of Economic Affairs.

4. Use procurement levers for supply chain resilience

The defence sector is well positioned to address supply chain vulnerabilities through procurement procedures given the relatively concentrated market and unique relationship between industry in the Netherlands, the EU and United States, and Ministry of Defence. Unlike other industries that serve thousands of commercial parties, the defence industry is closely collaborating with a small number of governmental clients. As such, the Ministry of Defence can design procurement procedures to incorporate criteria regarding supply chain resilience and thus push the industry to take steps in this direction. This should be implemented in a progressive way given that fulfilling such requirements takes significant effort from industry and will very likely increase operational costs and product prices.

5. Expand the defence industrial base

Coordination at both the national and international level should be prioritised to ensure a more consolidated and robust defence base. At the national level, collaboration among different ministries, especially Defence and Economic Affairs, is crucial to ensure policy coherence. Furthermore, cooperation with EU and NATO countries should be prioritised as it can support the optimisation of inventories for critical systems, address market fragmentation and overcome national protectionism in the defence sector.

Policy intervention options

There are various ways in which the five policy recommendations above can be operationalised. To support this effort, 24 distinct policy intervention options were developed. These are summarized in Table 1. Not all interventions can/should be implemented at the same time, but this is a long list from which the Ministries of Economic Affairs and Defence can choose the most fitting ones. Moreover, some of these interventions are included, either in a binding or non-binding form, in existing policy and strategic documents like the Critical Raw Materials Act, Net Zero Industry Act, European Defence Industrial Strategy, and so on. This research showed they are still not fully or effectively implemented in the Dutch defence sector, which is why they have been included below.

Table 1. Policy recommendations and intervention options to achieve resilient supply chains

Policy recommendations	Policy intervention options	Primary responsible actors
1. Enhance **awareness, understanding and skills**	1.1. Enhance awareness and understanding of supply chain risks in the defence sector within government.	1.1. EZ, MoD
	1.2. Create dialogue on CRM and supply chain risks within defence industry.	1.2. EZ, MoD, EU
	1.3. Create supply chain transparency for Dutch critical systems manufacturers in the defence sector.	1.3. EZ, MoD, BZK
	1.4. Invest in technical know-how for skilled workers in Dutch defence sector.	1.4. EZ, MoD, EU
	1.5. Invest in CRM alternatives for the defence sector (substitution).	1.5. EZ, MoD, EU, NATO
2. **Integrate the defence industry** in CRM-related activities	2.1. Involve MoD in policy development around supply chain resilience.	2.1. EZ, MoD
	2.2. Incorporate the interests of MoD and the defence industry in Dutch representation in European fora around CRM Act.	2.2. EZ, MoD, EU
	2.3. Increase defence involvement in existing international CRM agreements and initiatives.	2.3. EU
	2.4. Support ongoing domestic/ EU production incentives, including financial or regulatory support.	2.4. EZ
	2.5. Make connections between defence industry, commercial actors and CRM producers in Europe.	2.5. EZ
3. Improve **response** to supply chain disruptions	3.1. Create a roadmap with the industry, knowledge institutions and relevant governments for a circular and resilient LCF.	3.1. EZ, MoD
	3.2. Develop a defence crisis/contingency management plan in case of supply chain disruptions.	3.2. EZ, MoD, EU
	3.3. Enforce stress tests within defence industry including worst-case scenarios.	3.3. EZ, MoD, EU
	3.4. Manage existing inventory and optimise the stockpile of strategic critical components/systems.	3.4. MoD, EU, NATO
	3.5. Set up a stockpile for minerals and metals relevant for defence and other vital sectors.	3.5. EZ, EU
	3.6. Develop programs for circularity for military systems as part of the Dutch Raw Materials Strategy.	3.6. EZ, MoD
4. Use **procurement levers for supply chain resilience**	4.1. Impose requirements for supply chain risk assessments for critical system manufacturers.	4.1. MoD
	4.2. Impose requirements for origin for critical system manufacturers.	4.2. MoD, EU, NATO
	4.3. Impose requirements for circularity (R-ladder of strategies).	4.3. MoD
	4.4. Impose requirements to incorporate product passports for new systems.	4.4. MoD
	4.5. Impose diversification requirements for industry (components and systems).	4.5. MoD
	4.6. Impose requirements for design and standardisation.	4.6. MoD, EU, NATO
5. Expand the **defence industrial base**	5.1. Develop minimum manufacturing capacity for strategic components and systems.	5.1. EZ, EU, NATO
	5.2. Expand international defence production partnerships.	5.2. EZ, EU, NATO

Finally, the 24 policy interventions support the Dutch Raw Materials Strategy from December 2022 as shown below (Table 2).

Table 2. Mapping of policy interventions according to the strategic pillar in the Netherlands Raw Materials Strategy it supports

Policy Intervention	Strategic pillar in the Netherlands Raw Materials Strategy				
	Circularity & Innovation	Sustainable EU mining & processing	Diversification	Sustainable international supply chains	Knowledge development & monitoring
Enhance awareness, understanding and skills.	X			X	X
Integrate the defence industry in CRM-related activities.	X	X	X	X	X
Improve response to supply chain disruptions.	X		X		X
Use procurement levers for supply chain resilience.	X		X	X	X
Expand the defence industrial base.			X	X	

List of abbreviations

Abbreviation	English	Dutch
BZK	Ministry of the Interior and Kingdom Relations	Ministerie van Binnenlandse Zaken en Koninkrijksrelaties
CSDP	Common Security and Defence Policy	Gemeenschappelijk veiligheids- en defensiebeleid
CRM	Critical Raw Materials	Kritische grondstoffen
DIS	(Dutch) Defence Industry Strategy	Defensie Industrie Strategie
DRC	Democratic Republic of Congo	Democratische Republiek Congo
EU	European Union	Europese Unie
EZ	Ministry of Economic Affairs	Ministerie van Economische Zaken
IAMD	Integrated Air & Missile Defence	Geïntegreerde lucht- en raketverdediging
LCF	Air Defence & Command Frigate	Luchtverdediging- en Commandofregat
MoD	Ministry of Defence	Ministerie van Defensie
NATO	North Atlantic Treaty Organisation	Noord-Atlantische Verdragsorganisatie
NDIS	(US) National Defense Industry Strategy	Nationale Defensie Industrie strategie (Verenigde Staten)
NIDV	Netherlands' Industries for Defence and Security	Nederlandse Industrie voor Defensie en Veiligheid
NL	Netherlands	Nederland
NLDTIB	Dutch Defence- and Security related Technical Industrial Basis	Nederlandse defensie- en veiligheid gerelateerde Technologische Industriële Basis
R&D	Research & Development	Onderzoek en Ontwikkeling
REE	Rare earth elements	Zeldzame aardmetalen
SeWaCo	Sensors, Weapons and Communications	Sensoren, Wapens en Communicatie
SRM	Strategic Raw Materials	Strategische grondstoffen
SWOT	Strengths, Weaknesses, Opportunities & Threats	Sterkte-zwakteanalyse
UK	United Kingdom	Verenigd Koninkrijk
US	United States	Verenigde Staten

1. Introduction

Global tensions have renewed the interest of the European Union (EU) and member states like the Netherlands to invest in modernizing their militaries and revitalizing domestic industrial capabilities. The rise of China and the shift of the United States (US) strategic interest from Europe to the Indo-Pacific, Russia's military threat, and conflicts in the Middle East point to the need for European militaries to strengthen operational readiness and invest in the development of capabilities. The revitalization of conflict around Europe's borders – the Russo-Ukrainian war and the conflict in Gaza – has shown the EU and its member states that they must boost military operational readiness to be able to deter and/or withstand direct military confrontation.

At the same time, geopolitical tensions are putting pressure on trade relations, with implications for the supply security of strategic goods. Global supply chains have been strained ever since the COVID-19 pandemic and Russian invasion of Ukraine. These events have been wake-up calls for the EU that import dependencies in vital sectors – energy, healthcare, high-tech products – are undesirable and should be reduced. The escalating US-China tensions are bringing even more urgency for the EU to strengthen self-sufficiency. While the competition for economic, military, and technological superiority between the US and China has been unfolding for more than a decade, the rivalry has come to the forefront of global trade and national industrial policy. Especially when it comes to digital and energy technologies and the critical raw materials (CRM) used for their manufacturing, the US and China have been tightening legislation around exports. Since 2022, there has been an escalatory ladder of trade restrictions around semiconductors, chip-making technologies, and minerals, in which the Netherlands and Japan also participate alongside the US and China.[2] In May 2024, the Biden administration decided to substantially increase tariffs on imports of electric vehicles, batteries, metals and minerals, solar cells, and medical products.[3] This is causing the EU to take action toward becoming more self-sufficient in strategic sectors.

The EU is pursuing 'open strategic autonomy' – trying to become more autonomous in sectors of vital importance like energy, health, defence, high-technologies and space; while also acknowledging that interdependence with other countries cannot and should not be removed. Policies like the Chips Act, the Critical Raw Materials Act, the Net Zero Industry Act, the Defence Industrial Strategy, are all contributing to the goal of increased self-sufficiency paired with more trustworthy partnerships.

In the Netherlands, the framework coalition agreement of 2024-2028 pledges to enshrine in law the minimum contribution of 2% of the country's GDP to the NATO budget and to strengthen the Dutch and European defence industries.[4] In addition, the Maritime

2 Irina Patrahau, Lucia Van Geuns, and Tom Draaijer, 'Critical Raw Materials in the Dutch Province of Zuid-Holland: What, Why and How?', HCSS, 2024, https://hcss.nl/report/critical-raw-materials-in-the-dutch-province-of-zuid-holland-what-why-and-how/.

3 'FACT SHEET: President Biden Takes Action to Protect American Workers and Businesses from China's Unfair Trade Practices', The White House, 14 May 2024, https://www.whitehouse.gov/briefing-room/statements-releases/2024/05/14/fact-sheet-president-biden-takes-action-to-protect-american-workers-and-businesses-from-chinas-unfair-trade-practices/.

4 'Hoofdlijnenakkoord tussen de fracties van PVV, VVD, NSC en BBB' (Bureau Woordvoering Kabinetsformatie, 16 May 2024), https://www.kabinetsformatie2023.nl/documenten/publicaties/2024/05/16/hoofdlijnenakkoord-tussen-de-fracties-van-pvv-vvd-nsc-en-bbb

Manufacturing Industry Strategy of October 2023, which aims to revitalize the Dutch domestic maritime industry in support of both the defence and commercial sectors.[5] In this context, military security, climate adaptation, the energy transition and vital offshore infrastructure are priority sectors of strategic importance.[6]

Raw material supply chains are exposed to risks of disruption, which could compromise the defence sector.[7] CRM are most important minerals for the EU economy and have the highest risk of disruption at specific points in the supply chain.[8] Strategic raw materials (SRM) are a subset of CRM that is particularly important for strategic clean, defence and aerospace technologies.[9] The demand for CRM is increasing due to the energy transition, so there might be a scarcity of materials or an unexpected price increase that could hamper the defence sector's operations.

To support military objectives as well as the resilience of other vital sectors like energy, healthcare and digital technologies, the Dutch government has also introduced its National Raw Materials Strategy in December 2022 and the National Technology Strategy in January 2024. The Raw Materials Strategy is built on five pillars:[10]

(1) circularity and innovation
(2) sustainable European mining and processing
(3) diversification
(4) sustainable international supply chains
(5) knowledge development and monitoring

In the National Technology Strategy, imaging technologies, semiconductors, and photonics are mentioned to have specific applicability for the defence sector.[11]

In this rapidly evolving geopolitical context, the Netherlands' Ministry of Economic Affairs commissioned The Hague Centre for Strategic Studies (HCSS) and PwC to conduct research into the supply chain vulnerabilities of a specific military platform. The objective of this study is (1) to identify and analyse geopolitical vulnerabilities along the supply chain of the respective military platform, with a specific focus on CRM; and (2) provide policy recommendations for the Dutch government to build resilience and mitigate the risk of disruptions.

Reading guide

After detailing the research methodology in section 2, section 3 includes the LCF supply chain analysis. Based on this analysis, existing geopolitical vulnerabilities are discussed in section 4, both in terms of raw material extraction and processing, as well as component manufacturing. Section 5 introduces five categories of high-level policy recommendations and 24 policy interventions, followed by concluding remarks in section 6.

5 'No Guts, No Hollands Glorie! Sectoragenda Maritieme Maakindustrie', 2023, https://open.overheid.nl/documenten/700c6d90-4922-4ad5-ab4c-448853015fee/file

6 'No Guts, No Hollands Glorie! Sectoragenda Maritieme Maakindustrie'.

7 Benedetta Girardi et al., 'Strategic Raw Materials for Defence: Mapping European Industry Needs' (HCSS, 2023), https://hcss.nl/report/strategic-raw-materials-for-defence/.

8 'Critical Raw Materials', European Commission, 2023, https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials_en.

9 'Critical Raw Materials'.

10 Rijksoverheid, 'Grondstoffen Voor de Grote Transities', 2022, https://www.rijksoverheid.nl/documenten/kamerstukken/2022/12/09/bijlage-nationale-grondstoffenstrategie.

11 Ministerie van Economische Zaken en Klimaat, 'De Nationale Technologiestrategie', 2023, https://open.overheid.nl/documenten/67b0a9e1-135b-483f-9ed9-3aade270dbce/file.

2. Research method

This chapter provides an overview of the research questions, the rationale behind the selection of the military platform, the method employed to assess supply chain vulnerabilities, and the process through which policy recommendations have been formulated.

2.1. Research questions

This study answers the following two questions:

1. Which parts of the supply chain of the selected military platform bring dependencies on third countries and which of these constitute risks for the Netherlands?
2. What can the Dutch government do to prevent or mitigate these risks?

The two research questions are answered by following the approach described below:

- selecting a specific military platform for research
- identifying systems/components that are critical for the military platform's operational readiness and relevance
- mapping the supply chain of these components, sub-components and materials
- analysing geopolitical dependencies of the Dutch military and defence industry on other countries for (parts of) these supply chains
- determining which dependencies constitute risks and where there are opportunities for the Dutch government to intervene
- conducting a SWOT analysis of selected policy recommendations
- verification of the identified policy recommendations with the Dutch Ministry of Economic Affairs (EZ) and Ministry of Defence (MoD)

In the context of this research, the focus is on the case study of a military platform, but the approach outlined above should be replicable for other military platforms or systems in the future.

2.2. Selecting a military platform and specific systems as a case study

The selection of the military platform relied on the assessment of four criteria (see Table 1 below) that would maximize the feasibility of conducting the study as well as the relevance of the research for the Dutch government. The platform was selected based on access to information, its lifecycle timing, the focus of the Dutch government on strengthening its domestic industry, and the complexity of its offensive and defensive systems that make it representative for a wider range of platforms. Table 3 outlines the rationale and guiding questions that are used for each criterion.

Table 3. Criteria for choosing a specific military platform as a case study

	Criterion	Rationale	Guiding questions
1	**Access to information**	The extent to which the authors can access and make use of high-quality information about the military platform	• Do the authors have access to the Dutch defence industry? • Do relevant companies have material passports and are they willing to share them? • To what extent are standard-setters and system managers from the Netherlands' Ministry of Defence able to access and share information about the military platform? • Where are the key supply chain capabilities located? Are they located in the Netherlands or abroad? • To what extent is information about the system well-documented and easily accessible? This likely depends on system lifetime – more recent systems are expected to be easier to decompose as their information is more accessible (e.g. digitalised).
2	**Moment within the lifecycle**	The longer a system has been in use, the more representative it is likely to be regarding methodology and policy recommendations for all phases within the supply chain; and covers both short- and long-term possibilities for action	• How long has the system been in use? • Are there any updates planned? • Is it forecasted to be phased out soon (by 2030)?
3	**Industrial focus**	The extent to which the study contributes to strengthening the Dutch industry	• How does the military platform fit within the goals set in the Dutch Defence Industry Strategy (DIS)? • To what extent do industrial capabilities for producing / upgrading this military platform support existing (defence) industry in the Netherlands? • To what extent do industrial capabilities for producing / upgrading this military platform support emerging (defence) industry in the Netherlands?
4	**Complexity of the weapon systems**	The wide range of military system types (offensive/defensive, high-tech/low-tech) lends itself for a methodology that is in general easier to reproduce for a broad range of weapon systems, as well as covers a broad range of policy recommendations	• To what extent does the complexity of the system allow for a comprehensive analysis? • To what extent is it possible to break down the system into easily identifiable components? • Does the system include a satisfactory range of both newer and older technologies? • Does the system include a satisfactory range of both offensive and defensive capabilities?

This study is focused on the military-specific components and sub-components of the platform, particularly on weapons systems, sensors, command systems and electric technologies. As such, components that ensure the functioning of the platform itself, but which are not specifically of military nature are not included, since earlier studies have already been performed on non-military specific components and systems.[12]

To make a robust selection of systems and components to be analysed in this study, a set of criteria was developed (see Table 4). By selecting the most critical components for the platform, the analysis can address the most pressing and urgent needs when it comes to vulnerability to supply chain disruptions.

12 For an overview of the raw materials used in non-military specific components, see Pavel et al., Raw Materials Used in the European Defence Industry. For a high-level geopolitical assessment of the risks involving these materials, see Girardi et al., Strategic raw materials for defence: Mapping European industry needs.

Table 4. Criteria for selecting systems and (sub-)components for analysis

	Criterion	Explanation	Guiding questions/ assessment
1	**Military-specific character of the system**	The objective of the study is boosting military readiness	• What is the function of this system or (sub-)component?
2	**Criticality for military function**	This study focuses on dependencies that pose risks from a military perspective	• To what extent is the system or (sub-)component critical to the military function of the platform? • What is the lifespan/ -cycle of the system or (sub-) component? (i.e. hull vs high-tech system replaced or upgraded during lifespan)
3	**Representativeness for material dependence**	If the system uses a broad range of materials, it can be representative for other systems as well	• To what extent is the system or (sub-) component representative for the range of materials used within the defence industry?
4	**Feasibility within the study**	The extent to which information is available and accessible is crucial for the feasibility of this study	• To what extent is information regarding the makeup and supply chain of the system or (sub-)component available to the authors?

2.3. Analysis of supply chain vulnerabilities

After selecting the most relevant systems to be analysed, this study uses various indicators to assess vulnerabilities. These are outlined below.

Vulnerabilities in the mining and processing of CRM

The framework below is employed to assess the likelihood of supply disruption in the mining and processing of the raw materials (Table 5).

The assessment of the likelihood for disruption for each material was conducted by assigning a score between 1-3 to each indicator (where 1 signifies low disruption likelihood and 3 high disruption likelihood), and calculating a weighted average in the following way:

1. Supply chain indicators are assigned a value from 1-3. An average is made for supply chain vulnerability.
2. Geopolitical relations indicators are assigned a value from 1-3. A weighted average is calculated based on geopolitical relations scores and the respective share of global production that a supplier has. For instance, if Country X has a 70% share of global production, the geopolitical relations vulnerability associated with Country X accounts for 70% of the final score.
3. The final likelihood assessment is the average between supply chain and geopolitical relations vulnerability scores.

Finally, if the supply of a material is diversified – rather than controlled by a small number of players – the material receives the assessment of very low likelihood of disruption and a score is not calculated.

Table 5. Assessment framework for the likelihood of supply disruption

	Indicator	Guiding question	Measurement of indicator	Data
SUPPLY CHAIN	**Supply concentration**	To what extent is global supply geographically concentrated?	Market share (%) of top three global producing countries (extraction and processing)	EU Study on the CRM list 2023
	Recyclability	What percentage of (European) demand can be supplied with secondary materials?	End of Life Recycling Input Rate	EU End of Life Recycling Input Rate (EoL-RIR) (Annex 1)
	Substitutes	Are there available substitutes to the material?	Substitution score	EU Substitution Index for supply risk (Annex 5 SR)
GEOPOLITICAL RELATIONS	**Supplier country stability**	To what degree are the top global suppliers stable countries or located in stable countries?	Fragile State Index (FSI) score	Fragile States Index
	Economic relationship with suppliers	What is the economic relationship between top global suppliers and the Netherlands/EU?	Trade Intensity score	Trade Intensity Index from the World Integrated Trade Solution platform of the World Bank
			Trends in bilateral foreign direct investment flows; (Regional) Investment strategies; (Content of) existing trade deals; Discourse of officials; Export controls/bans	Qualitative
	Political relationship with suppliers	To what extent can the top 3 suppliers realise its desired outcomes in the international system?	Global Power Index (GPI)	Global Power Index
		To what extent can the Netherlands influence the top 3 suppliers?	Relational power in the international system	Pardee Formal Bilateral Influence Capacity Index
		What is the political relationship between top global suppliers and the Netherlands/EU?	Regional strategies; Government official discourse; Political stability in both States (shift in domestic Political situation can result in different bilateral relations); Cooperation in global fora between States; Historical relations	Qualitative
	Military relationship with suppliers	What is the military relationship between top global suppliers and the Netherlands/EU?	Arms trade; Ongoing conflicts, Military alliances; Military exercises	Qualitative

Vulnerabilities in component manufacturing and maintenance

To assess the likelihood of disruption to the supply chain at the level of component manufacturing and maintenance, the report analyses relations between the Netherlands and supplier countries by using the following indicators:

a. The status of military cooperation between the foreign state and the Netherlands, including:
   i. military cooperation under international frameworks (e.g., the EU, NATO)
   ii. integration of the two states' forces
   iii. joint exercises and initiatives

b. The status of economic cooperation between the foreign state and the Netherlands, including:
   i. trade between the two countries
   ii. investment flows
   iii. sectoral cooperation

c. The status of overall relations, including potential points of tensions

Generalized framework for supply chain analysis of MoD platforms

The methodology applied for supply chain analysis of the LCF can be generalized into a framework for future analyses of other MoD platforms. This framework consists of four steps:

1. system breakdown and (sub)system criticality analysis
2. tier-1 supplier identification
3. data collection from tier-1 suppliers
4. analysis of raw materials and supply chain vulnerabilities

Step 1: System breakdown and (sub)system criticality analysis

This step consists of three sub-steps:

1. a functional breakdown
2. a system breakdown
3. a prioritization of critical (sub)systems

The goal of this step is to understand the structure and functionality of the MoD platform, and to identify the most critical systems for its performance and availability. Supply chain dependencies are to be analysed for the specific set of critical systems. To determine the set of critical systems, several criteria are proposed in Table 6, of which the first criterion was part of the study on the LCF supply chain.

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Table 6. Criteria for selecting critical systems for analysis

	Criterion	Explanation	Guiding questions/ assessment
1	**Criticality for military function**	Identify dependencies that pose risks from a military perspective	• To what extent is the system or (sub-)component critical to the military function of the platform?
2	**Replacement interval for systems**	Identify systems that have a high(er) need for materials during the lifespan of the platform	• What is the lifespan/ -cycle of the system or (sub-) component? (i.e., hull vs high-tech system replaced or upgraded during lifespan)
3	**Short term risks**	Identify short term risks and the capacity to mitigate them	• To what extent is the stockpile of spare parts sufficient to overcome a short term disruption? • To what extent does the Netherlands and allied countries manufacturing capacity to react to the short term disruption?
4	**Long term risks**	Identify long term risks and the capacity to mitigate them	• What are alternatives for replacing the system in the long term? • Are there alternative suppliers for the system?

This data is present at the MoD at the weapon system manager level.

Step 2: Tier-1 supplier identification for critical systems

This step involves finding out the names and locations of the companies that provide the main components and subsystems of the defence system. The goal of this step is to establish the first level of the supply chain of the defence system, and to prepare for the data collection from the suppliers.

This data is present at the MoD at the sustainment departments and weapon system manager.

Step 3: Data collection from tier-1 suppliers

This step involves information requests to the tier-1 suppliers, asking for data on supply chain information on the respective (sub)systems, such as CRM content (by means of material passports) and origin of their products. The goal of this step is to obtain specific and detailed information on the CRM use and sourcing of the defence system, and to identify the main CRM suppliers and countries of origin. This step also involves analysing the responses from the tier-1 suppliers and identifying the gaps and limitations in the data.

The main data source for this step is the defence industry.

Step 4: Analysis of raw material and supply chain vulnerabilities

This step consists of an analysis of geopolitical dependencies and vulnerabilities along the supply chain of the respective platform. Depending on the information that the defence industry is able and willing to share, the depth of the analysis may vary. Ideally, key suppliers of subsystems and raw materials are identified, allowing for a relatively comprehensive study. This step consists of:

1. the application of the framework for the likelihood of supply disruption presented in Table 5 Assessment framework for the likelihood of supply disruption for the raw and processed materials
2. the analysis of the (geo)political, economic and military relations between the Netherlands and countries that supply the systems and subsystems

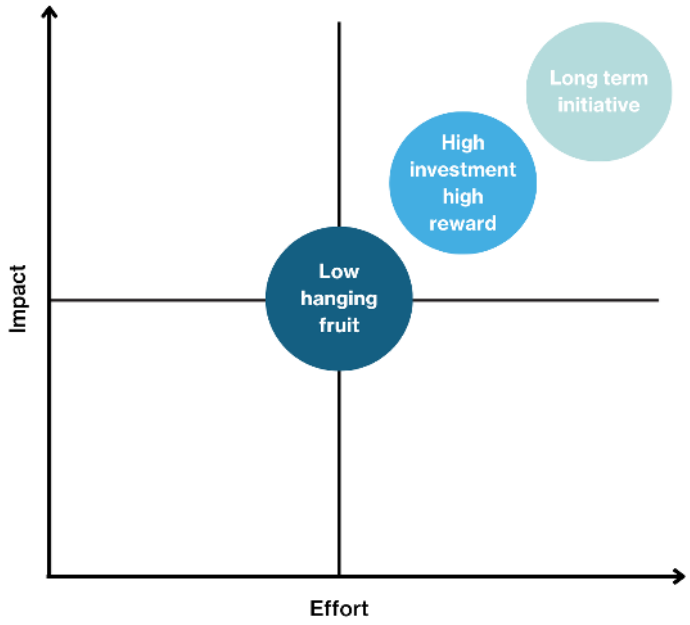
2.4. Defining and assessing policy interventions

After defining high-level policy recommendations, a diverse set of policy interventions was formulated and assessed using the SWOT methodology. Interventions were defined based on the results of the analysis as well as desk research of policies of other countries, for instance the US National Defence Industrial Strategy (NDIS).[13] The four categories that emerged are described in Table 7. Given that enabling interventions are expected to have an indirect positive effect on supply chain vulnerabilities, only the first three are qualitatively categorized in terms of impact and effort as shown in Figure 3.

Table 7. Policy interventions categories

	Category	Description
1	**Low hanging fruit**	Defence-specific intervention that is expected to directly (short term) lead to some effect and can be taken with limited resources.
2	**High investment, high reward**	Defence-specific intervention that is expected to lead directly to major effect, but only with significant resources.
3	**Long term initiative**	Intervention aimed at long term effect (years), or which can only be implemented in the long term. Requires significant resources and has major effects.
4	**Enabler**	Intervention that enables other interventions but does not result in direct effect on its own. Policy interventions can be Enablers while being in another category as well.

Figure 3. Impact & effort of intervention options



13 'The National Defense Industrial Strategy (NDIS)', Industrial Base Policy, accessed 26 July 2024, https://www.businessdefense.gov/NDIS.html.

Moreover, a SWOT was set up for each of the policy interventions and was verified and validated with representatives from the Dutch Ministry of Economic Affairs and Ministry of Defence in July 2024. A SWOT is a qualitative analysis method describing strengths, weaknesses, opportunities, and threats. The following questions were answered when describing each of these aspects of the SWOT:

- **Strengths**: What strengths of the responsible actor can support this intervention?
- **Weaknesses**: What weaknesses of the responsible actor can limit the effect of this intervention?
- **Opportunities**: What can be other added benefits of this intervention?
- **Threats:** What can be a negative effect of this intervention?

3. Supply chain analysis of the LCF platform

Key Takeaways

- The MoD has a very well documented functional and (tier-1) system breakdown of the LCF, enabling the identification of critical systems for the LCF's functioning. Further prioritization on the criticality of systems could be done by looking at the replacement intervals of components/ (sub)systems.
- The MoD does not have access to supply chain information of the LCF beyond tier-1 suppliers.
- Tier-1 system suppliers for military systems in the LCF are either EU or NATO countries.
- Tier-1 system suppliers interviewed for this study appear not to be fully aware of supply chain dependencies, specifically to the level of CRM.
- For the LCF, no cases of supply chain disruptions are known that can be attributed to CRM dependencies. Obsolescence is an attention point since the LCF is nearing its end-life-of-type, but this is not (known to be) caused by risks connected to supply chain dependencies.

The platform of choice for this study is the Air Defence & Command Frigate (Luchtverdedigings- en Commando Fregat - LCF). This chapter gives an overview of the LCF, shows the criteria used for choosing this platform, and outlines the system break-down used for the analysis.

3.1. The LCF-platform – an overview

The Royal Navy has four Air Defence & Command Frigates of the Zeven Provinciën class: Zr. Ms. Zeven Provinciën, Zr. Ms. Tromp, Zr. Ms. De Ruyter and Zr. Ms. Evertsen. The vessels can protect an entire fleet against enemy threats from the sea and air (including aircraft, drones and missiles) and have an extensive weapon arsenal.[14]

LCFs belong to the most advanced and versatile maritime platforms that are currently in operation. The main characteristics of an LCF platform are shown in Table 8. They can destroy enemy surface vessels and land targets, and defend against hostile aircraft, missiles and submarines. Furthermore, the LCF is equipped to allow a full operational staff for commanding large-scale maritime operations.

Figure 4. Top left: Overview image of the LCF at sea; Top right: Goalkeeper close-in weapon system, Bottom left: Firing of an ESSM; Bottom right: SMART-L radar system (source: www.defensie.nl)

14 'Luchtverdedigings- en commandofregat (LCF)', Ministerie van Defensie (Ministerie van Defensie, 22 June 2023), https://www.defensie.nl/onderwerpen/materieel/schepen/luchtverdedigings--en-commandofregatten-lcf.

The LCF was introduced in 2002 and since then they have been frequently deployed during their service in NATO fleet formations such as the Standing NATO Maritime Group 1 (SNMG1) and SNMG2. In the past, the frigates also performed anti-piracy missions off the coast of Somalia.[10] More recently, Zr. Ms. Tromp participated in Pacific Archer '24 for protection of vessels on the Red Sea. The LCF is an expeditionary platform, meaning it can operate world-wide and autonomously for prolonged periods. Currently, the MoD is preparing for procuring the LCF's successor: the Future Air Defender (FuAD).

Table 8. Characteristics of the LCF platform[14]

Manufacturer	Damen Schelde Naval Shipbuilding
Displacement	6.050 tons
Length	144 m
Width	17 m
Draft	7 m
Speed	30 knots
Crew	174 (202 including staff)
Radar	Modernised SMART-L Early Warning (EW) capability
Weapons	Oto Breda 127 mm canon Mk41 vertical launch system for Evolved Sea Sparrow Missile (ESSM) and Standard Missile 2 Block III-A (SM-2) Harpoon anti-ship missile Goalkeeper close in weapon system Mk46 torpedoes NH90 maritime helicopter

3.2. Criteria for choosing the LCF

As introduced in Section 2, four criteria have been assessed to choose a specific platform for supply chain analysis. Table 9 provides more detail on the rationale behind choosing the LCF at the platform of choice for this study.

Summarizing, the strong focus of the Defence Industrial Strategy on the maritime domain and the ease of access to information narrowed the search for suitable platforms to the maritime domain, specifically to surface vessels. The desire to look at supply chains of military-specific offence and defensive systems of the platform in focus, resulted in choosing the LCF as the platform of choice for this study. The LCF has both offensive and defensive capability with a variety of weapon systems, sensors, and communication equipment, and is a vessel with a relatively high share of Dutch designed/made systems on board.

Table 9. Rationale behind choosing the LCF

	Criterion	Rationale behind choosing the LCF
1	**Access to information**	The Netherlands' existing defence industrial capabilities facilitate easy access to information. Open-source research shows that certain supply chain capabilities of the LCF are located in the Netherlands. The LCF type of frigate has been in use since 2002, meaning that more information, also open source, is available on this system rather than newer systems/ systems that are yet to be delivered such as the Anti-Submarine Warfare Frigate (ASFW). Furthermore, the MoD has a high-quality information record on the maritime platforms which should facilitate the supply chain analysis. Additionally, potential interviewees are more likely to be able to provide information on a system that has been part of the Dutch fleet for more than 20 years.
2	**Moment within the lifecycle**	The four LCFs in the Dutch fleet are relatively recent (2002-2005) and have been upgraded to ensure they are still fit for purpose. They are expected to receive more updates in the coming years, but they will not be completely replaced (like in the case of the ASWF replacing the M-Frigate). To boost situational awareness of these processes, it is important to gain a better understanding of supply chain dependencies.
3	**Industrial focus**	The DIS published in 2018 aims to strengthen knowledge and capabilities in the Netherlands to protect its national security interests. The recent Sector Agenda for the Maritime Industry in the Netherlands emphasizes the importance of maritime military platforms for the Dutch domestic industry. Past involvement of the Dutch naval industry with the LCF systems is also to be considered. For instance, Damen was already involved in the past in repairs for HNLMS Evertsen, one of the LCFs, so the Dutch industry is already acquainted with LCF systems.
4	**Complexity of the weapon systems**	The LCF is a complex system with diverse types of weapons systems and sensors, making it representative for the wider defence (maritime) industry. Policy recommendations are therefore expected to be applicable in a more general sense to other platforms of the MoD. Upcoming updates to the LCF make it possible to consider newer technologies, while the fact that LCFs have been in service since 2002 allows for a wide range of consolidated technology to be included in the analysis framework.

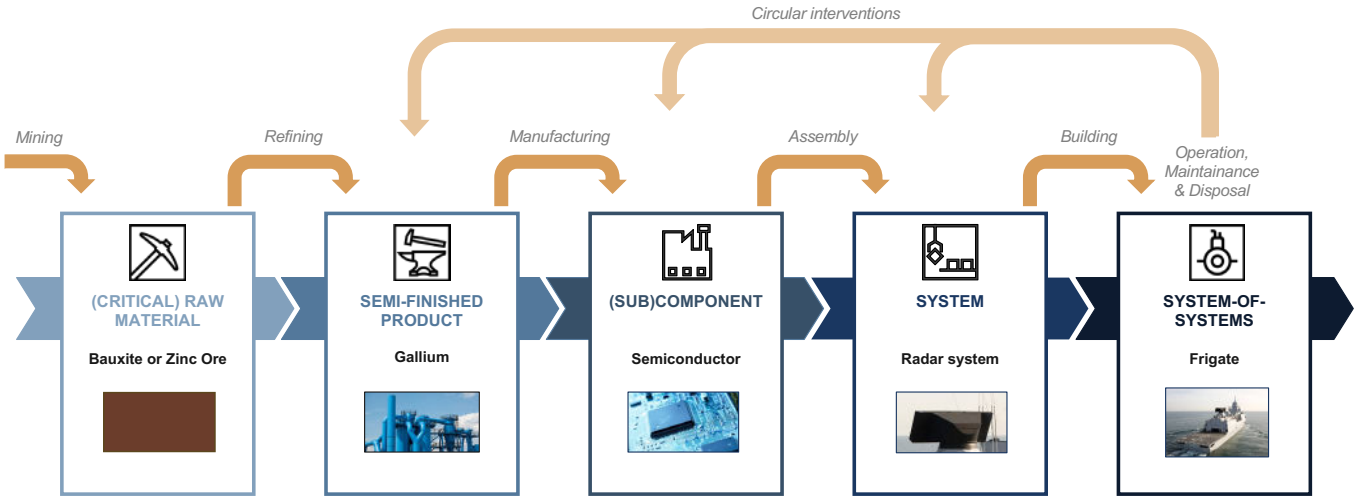
3.3. The LCF supply chain

Mapping the supply chain of an LCF requires the identification of systems, components, and raw materials, as well as of their supply chains. Figure 5 below shows a simplified version of a supply chain for one of the raw materials used in the radar system in the LCF.

The raw materials are sourced from mines around the world and refined into high-purity semi-finished products. The refining of the raw material into semi-finished products is complex and often involves several processes to reach the required purity levels and physical characteristics. For instance, semiconductors require silicon to be made into high-purity polysilicon, which is often done in highly specialized facilities. The mining and refining of certain raw materials are highly concentrated in a few countries, introducing a potential supply risk (see Section 4). The semi-finished products are used by manufacturers to produce sub-components and, in turn, components.

The supply chain of defence applications can be characterised in terms of the roles of different actors: different players handle the raw materials, manufacture sub-components, assemble components, and are system integrators. Up to a certain point in the supply chain, there is notable overlap between the civil and defence industries. Especially when it comes to the functioning of the ship itself, the defence industry relies heavily on civil commercial companies, with the caveat that the technologies and systems must fulfil high reliability and operational standards. Even in the case of military-specific technologies, components may be dual-use and sourced from commercial actors. Still, the last stages of the supply chain, including manufacturing military-sensitive technologies and their assembly is done by the defence industry.

Figure 5. Example of the supply chain for a radar system on the LCF[15]



Altogether, the number of components in a maritime platform can reach the order of thousands to even millions and will involve a large number of players over the supply chain across the globe. For example, a submarine can contain over half a million individual components.[16]

Therefore, for this study a selection of systems to investigate is made based on the criteria listed in chapter 2:

1. military-specific character of the system
2. criticality for functioning of the platform
3. representativeness for material dependence
4. feasibility within the study (access to information)

Identifying military-specific systems and assessing criticality for functioning of the platform

Systems within a maritime platform are typically grouped in platform systems on the one hand, and sensors, weapons and communication systems (SeWaCo as an abbreviation of "*Sensoren, Wapens en Communicatie*") on the other hand. Platform systems are necessary systems for any maritime ship like the engine or the hull. The MoD uses a functional breakdown of the LCF to group systems into either the platform or SeWaCo category. The functional breakdown of the LCF is included as a separate Annex 3 to this document due to the classification of the information. Table 10 shows a generic functional breakdown of the systems of a maritime platform.

15 Image source for radar system and frigate: defensie.nl

16 Verdi Ogewell, 'How Saab Kockums Manages 600,000 Parts to Build Its A26 Submarine', Engineering.com, 17 April 2024, https://www.engineering.com/how-saab-kockums-manages-600000-parts-to-build-its-a26-submarine/.

Table 10. Generic functional breakdown of a maritime platform

Function	Sub-function	Example of system types
Platform	Auxiliary	Pumps, compressors
	Mobility	Hull, propellors, engine
	Hotel	Accommodation, air conditioning
	Survivability	Safety and medical functions
	Representation	Ceremonial functions
SeWaCo	Command, Control & Intelligence (C2I) support	Data processing and storage
	Navigation	Navigation equipment
	Communication	Communication equipment
	Self Defence	Self-defence against air, surface and subsurface threats
	Integrated Air & Missile Defence	Systems for Air & Missile Defence
	Anti Submarine Warfare	Systems to (counter)attack submarines
	Anti Surface Warfare	Systems to (counter)attack surface vessels
	Helicopter Operations	Systems onboard the ship to enable operation with NH90 maritime helicopter (not the helicopter itself).
	Armament[17]	Missiles, torpedo's, ammunition

Given the more general nature of systems in the platform function, this research focused specifically on the functional and system breakdown of the SeWaCo function. Figure 6 shows an example of the system breakdown for the Integrated Air & Missile Defence subfunction. Due to the classification of this information, the complete system breakdown is included as a separate Annex 4. This annex gives a detailed overview of the systems and their tier-1 supplier(s), insofar the information was available to the researchers. All primary systems linked to the subfunctions are considered vital by the MoD for functioning of the LCF.

Although not performed in this study, further prioritization on systems that are critical for the platform's functioning could be done by looking at the maintenance / replacement intervals. These intervals determine when components or complete systems need to be replaced. The demand for components/systems over the lifetime of the platform determines the total life cycle demand for CRM for the given platform. Components/systems that have a higher replacement interval form a higher risk than systems that do not have to be replaced, such as the hull.

17 Armament was included in the research scope additional to the functional breakdown due to its vital role in fulfilling the LCF's operational role and known Defence-specific CRM dependencies on ammunition.

Figure 6. Breakdown of the LCF in functions, subfunctions of SeWaCo, technical functions and systems, example for Integrated Air & Missile Defence (IAMD)

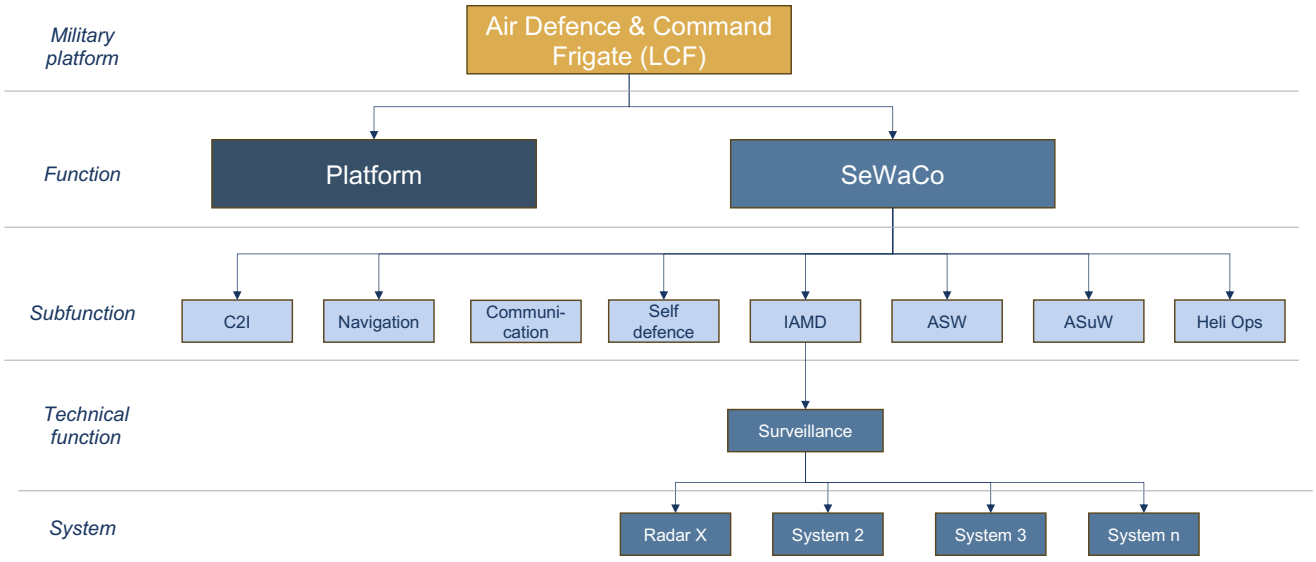
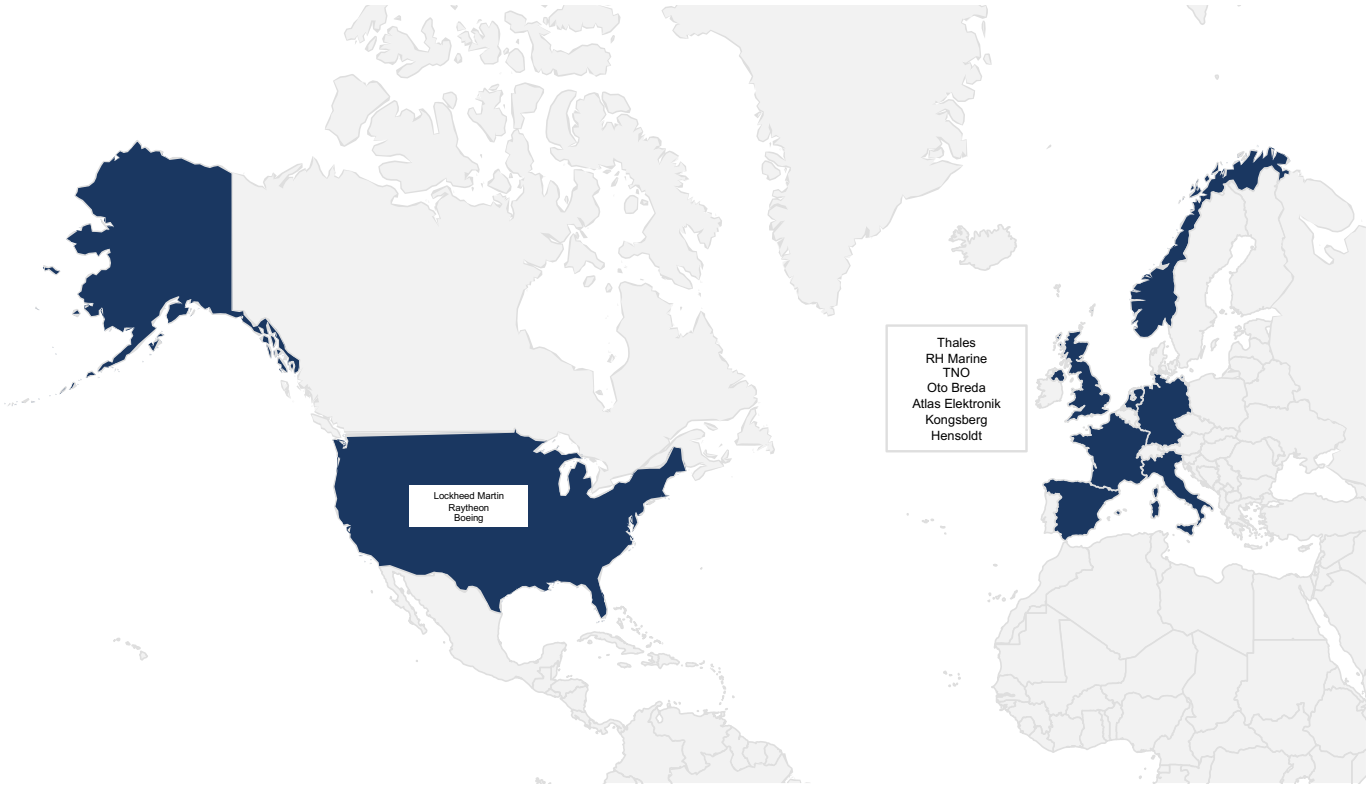


Figure 7 shows the countries of origin of the tier-1 suppliers for the most important SeWaCo systems. These tier-1 suppliers are located either in EU- or NATO-countries.

Figure 7. Countries of origin and their tier-1 suppliers



Information on CRM dependencies within critical systems

No information was found to be present at the MoD on the rest of the supply chain, including raw material dependencies. The primary need of the MoD for repair capacity, supply of spare parts and supply of new systems solely requires direct interaction with tier-1 suppliers. The tier-1 suppliers on their end are responsible for managing the supply chain and guaranteeing the availability of spare parts during the lifetime of the respective systems. Up until today, the MoD has not encountered supply disruptions that can directly be related to specific CRM dependencies. Obsolescence of spare parts (for example caused by cessation of a production line for a certain spare part of system) is currently a more pressing attention point, since the LCF is nearing its end- life-of-type (ELOT). Since tier-1 suppliers are in general responsible for proposing solutions on obsolescence cases, this has not required further insight or control by MoD on the supply chain beyond tier-1 suppliers.

Information requests were sent to the tier-1 suppliers to obtain further insight into the CRM dependencies. The research team approached several of the tier-1 suppliers, focussing on suppliers that either have a large share of systems and/or which could be approached within the boundaries of this study. None of the information requests however led to a deeper insight on dependencies on CRM. Most suppliers were responsive but did not have the information on CRM dependencies readily available to deliver to the researchers. One of the suppliers has responded that for legacy systems the information on CRM dependencies is not present, but they will likely implement this for new systems in the future.

For this reason, the researchers in consultation with EZ decided to rely on more generic information about raw materials found in military maritime platforms and armament, as well as on the relations between the Netherlands and the country of origin of tier-1 suppliers and a framework for future supply chain analysis on MoD weapon systems. The policy interventions were formulated based on the finding that available information on CRM dependencies within the LCF is very scarce; and on the open-source research presented in the next section.

4. Geopolitical dependencies and vulnerabilities

Key Takeaways

- The supply chains of 29 materials have been analysed. Of these, 21 of are part of Europe's 2023 lists of critical and strategic materials.
  - Five materials are considered to have a high likelihood of disruption: gallium, germanium, magnesium, and two rare earth elements, samarium and neodymium. All these materials have a highly concentrated supply base in China, both in terms of their extraction and processing. Except for magnesium, they have all been affected by Chinese export regulations since 2022, which is why the likelihood of a supply disruption is high. Magnesium supply has also been under pressure due to power cuts in China in the second half of 2022, which caused issues for the European aluminium industry who almost ran out of inventories.
  - Thirteen materials are considered to have a medium likelihood of disruption. Except for tungsten and niobium, the supply base of most materials is quite diversified. They tend to be produced (1) in likeminded countries like Australia, but in relatively small proportions compared to other producers; (2) in countries that face domestic instability, like Guinea, the Democratic Republic of Congo (DRC), or Kazakhstan; (3) in countries that have complex positions in the broader geopolitical landscape, like the US, South Africa, China and Russia.
  - Ten materials have been assessed with a low likelihood of supply disruption compared to the others, six of which are not part of the EU's critical and strategic materials list. The supply of these materials may still be vulnerable to disruptions, but they tend to have diversified supply bases and a relatively high portion of the demand can be supplied with secondary materials.
  - Gold is considered to have very low likelihood of disruption.

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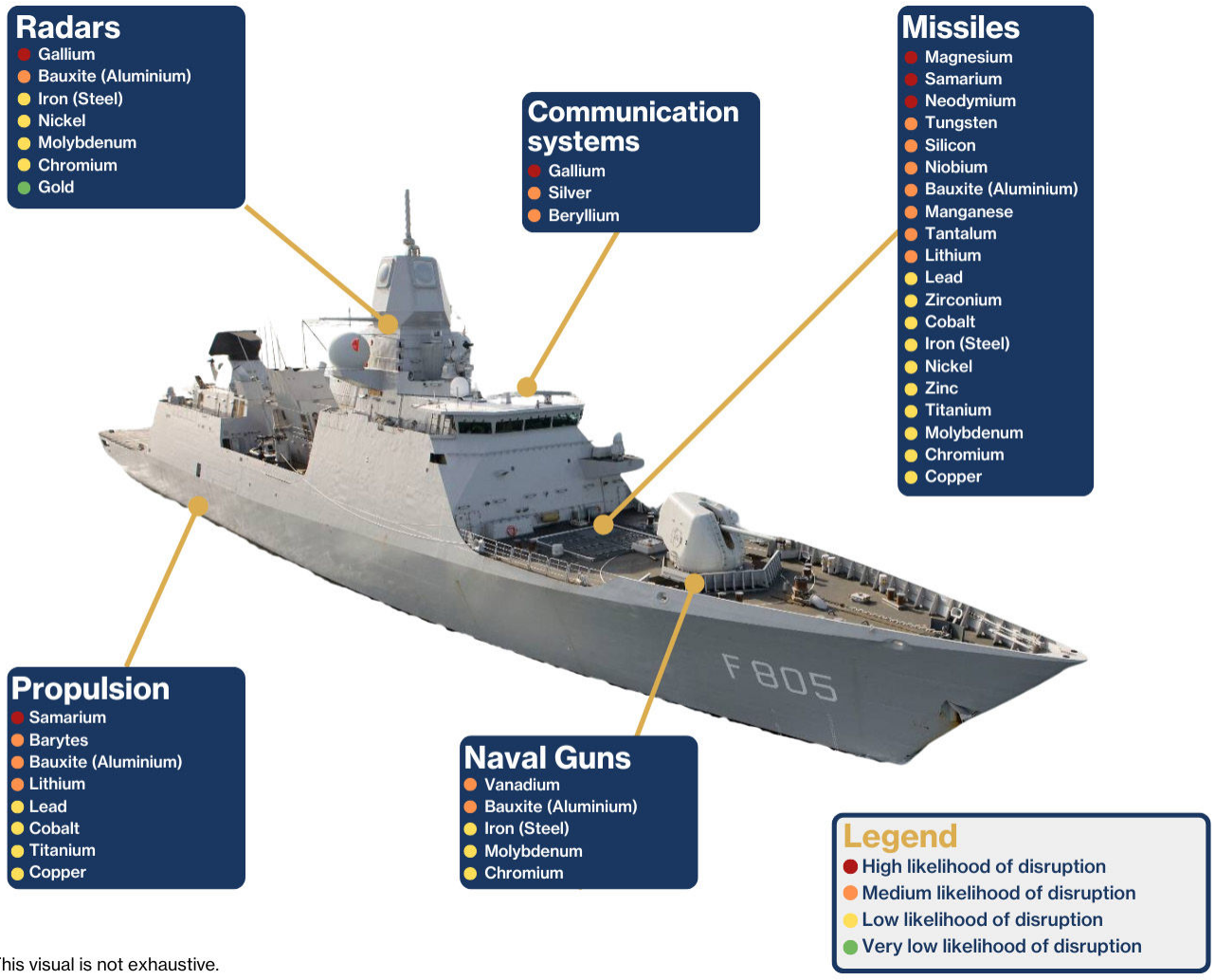
- Semiconductors play a crucial role in the defence sector, powering a wide array of advanced military technologies. These components are fundamental to the operation of communication systems, radar, and electronic warfare equipment, enhancing the capabilities and effectiveness of defence operations. As the materials needed for manufacturing semiconductors are sourced in unstable or politically unreliable countries, the likelihood of a supply disruption is high.

- The Netherlands' procurement of critical components for the LCF is supported by strong and multifaceted relationships with key partner countries, including Finland, France, Germany, Italy, Norway, the United Kingdom (UK), and the US.
  - The Netherlands enjoys strong and stable relationships with the key supplier countries. These partnerships are underpinned by robust economic, military, and political ties, often framed within broader EU and NATO initiatives. This stability is likely to ensure a reliable supply of critical components for the LCF.
  - Evolving geopolitical conditions should be continuously monitored, as they may impact the procurement of critical components. Finland's recent NATO membership could increase the demand for certain critical systems and that might impact defence procurement for other countries. The upcoming US elections could influence Dutch-US relations, especially if there are significant political shifts.
  - Amid increasing Sino-American competition and the Russian aggression in Ukraine, there is an increasing tendency towards protectionism. Monitoring the rise in protectionist policies and the possible impact on international procurement is crucial for ensuring the uninterrupted supply of critical components for the LCF.

4.1. Raw & processed materials

The LCF contains various raw materials that are processed into semi-finished products and used in the manufacturing of sub-components and components. A total of 29 materials have been included in the assessment (see Table 11 and Figure 8). These materials are generally used in the components of military ships (radars, naval guns, etc.), but the information was collected from publicly available sources and not from specific LCF documentation. As such, due to data scarcity, the list is not exhaustive.

Figure 8. Raw materials in the Air Defence and Command Frigate (LCF)



Note: This visual is not exhaustive.

Many of the materials are already part of the 2023 lists of critical and strategic raw materials of the EU.[18] While the other 8 are not officially on the list, they are nonetheless important materials for defence applications, so they have been included in the assessment. The exception is gold, whose top three suppliers control about 30% of global production. Given that its supply base is highly diversified, the likelihood of disruption for gold is considered very low and a score has not been calculated.

The likelihood of supply disruption for the 28 materials has been categorised in four levels: high likelihood of disruption, with final scores of over 2,5; medium likelihood of disruption, with final scores between 2,00 and 2,49; low likelihood of disruption, with final scores under 1,99. The scores are calculated using the assessment framework presented in Section 2. For each material at both the extraction and processing stage, quantitative and qualitative indicators have been analysed and scored. The final score consists of weighted averages of material-specific indicators and geopolitical indicators and is illustrated in Table 11.

18 'Critical Raw Materials', European Commission, 2023, https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials_en.

Table 11. Results of the assessment of the likelihood of supply disruption per material, their main uses in the LCF and top global producers

	Material	Score	Part of 2023 EU CRM/SRM list	Main uses in the LCF[19]	Top global producers of raw materials (2023)[20]	Top global producers of processed materials (2023)[21]
High likelihood of disruption	**Gallium**	**2,71**	Yes	Semiconductors; Radars; Communication systems	N/A	China 94% Ukraine 2% Russia 2%
	Germanium	**2,71**	Yes	Semiconductors	N/A	China 83% Russia 5% Belgium 4,5%
	Magnesium	**2,69**	Yes	Missiles; Flares and incendiary bombs; Aluminium alloys for naval structures and missile frame	N/A	China 90,6% United States 3,4% Israel 2,2%
	Samarium - Light rare earth element	**2,54**	Yes	Missiles; Electric motors for propulsion	China 68,3% Australia 9,9% United States 9,2%	China 84,9% Malaysia 10,5% Russia 1,9%
	Neodymium-Light rare earth element	**2,54**	Yes	Missiles (propulsion)	China 68,3% Australia 9,9% United States 9,2%	China 84,9% Malaysia 10,5% Russia 1,9%
Medium likelihood of disruption	**Tungsten**	**2,42**	Yes	Missiles; Bullets	China 82,6% Vietnam 6,4% Russia 2,7%	China 85,6% United States 4,4% Russia 2,8%
	Vanadium	**2,32**	Yes	Special steels for naval guns	China 61,6% Russia 19,8% South Africa 10,6%	China 61,5% Russia 9% South Africa 8,2%
	Silicon	**2,25**	Yes	Missiles; Semiconductors Aluminium alloys for naval structures and missile frame	United States 41% China 8% India 5%	China 76% Brazil 7% Norway 6%
	Barytes (Barium)	**2,24**	Yes	Electric motors for propulsion	China 31,5% India 25,1% Morocco 8,9%	N/A
	Niobium	**2,19**	Yes	Missiles	Brazil 91,8% Canada 6,6% Russia 0,6%	Brazil 88,8% Canada 11,2%
	Palladium	**2,16**	Yes	Semiconductors	N/A	Russia 40% South Africa 36% Canada 10%
	Silver	**2,10**	No	Communication systems	Mexico 24% Peru 14% China 13%	N/A

19 *Claudiu C. Pavel and Evangelos Tzimas, 'Raw Materials in the European Defence Industry' (LU: Publications Office of the European Union, 2016), https://data.europa.eu/doi/10.2790/0444; 'PYRAD53NW', Aubert & Duval, accessed 22 August 2024, https://www.aubertduval.com/alloy/738/; Chin Trento, 'Six Strategic Metals Widely Used in the Military Industry', Stanford Advanced Materials, April 2024, https://www.samaterials.com/content/six-strategic-metals-widely-used-in-the-military-industry.html. Justin Rowlatt, 'Tungsten: The Perfect Metal for Bullets and Missiles', BBC News, 11 July 2014, sec. Magazine, https://www.bbc.com/news/magazine-28263683.*

20 European Commission et al., 'Study on the Critical Raw Materials for the EU 2023 - Final Report', 2023, https://data.europa.eu/doi/10.2873/725585.

21 European Commission et al.

	Material	Score	Part of 2023 EU CRM/SRM list	Main uses in the LCF[19]	Top global producers of raw materials (2023)[20]	Top global producers of processed materials (2023)[21]
Medium likelihood of disruption	**Bauxite (Aluminium)**	**2,08**	Yes	Missiles; Naval guns; Radars; Shafts & Driving controllable pitch propellers for propulsion; Special steels for naval components and structure parts; Aluminium alloys	Australia 28% China 21% Guinea 18%	China 56% Russia 6% India 6%
	Boron (Borate)	**2,04**	Yes	Missiles	Turkiye 48,4% United States 24,9% Chile 10,7%	Turkiye 44,8% United States 23,4% Chile 10%
	Manganese	**2,04**	Yes	Missiles; Aluminium alloys for naval structures and missile frame	South Africa 29,3% Australia 16,3% Gabon 14,4%	China 58,2% India 13,1% Ukraine 4,4%
	Tantalum	**2,04**	Yes	Missiles	DRC 35,4% Rwanda 17,3% Brazil 15,9%	N/A
	Lithium	**2,04**	Yes	Missiles (propulsion & guidance section); Electric motors for propulsion	Australia 53% Chile 24,1% China 10,2%	China 56,2% Chile 32,1% Argentina 10,5%
	Beryllium	**2,00**	Yes	Communication systems	United States 67,3% China 26% Mozambique 3,6%	United States 50,2% Kazakhstan 25% Japan 16,9%
Low likelihood of disruption	**Lead**	**1,97**	No	Missiles (propulsion); Electric motors for propulsion	China 43,4% Australia 9,8% United States 6,4%	China 43% United States 9,5% South Korea 6,7%
	Zirconium	**1,96**	No	Missiles	Australia 33,6% South Africa 23,4% Mozambique 11,2%	N/A
	Cobalt	**1,95**	Yes	Missiles; Electric motors for propulsion	DRC 62,8% Russia 6,6% Canada 4,1%	China 59,6% Finland 11,4% Belgium 5,3%
	Iron (Steel)	**1,94**	No	Special steels for radars and missile propulsion; Special steels for warheads; Special steels for naval guns; Aluminium alloys for naval structures and missile frame	Australia 37% Brazil 18% China 15%	China 52% India 6% Japan 6%
	Nickel	**1,90**	Strategic raw materials list	Special steels for radars and missile propulsion; Shafts & Driving controllable pitch propellers for propulsion	Indonesia 26% Philippines 14% Russia 10%	China 33% Indonesia 12% Japan 9%
	Zinc	**1,86**	No	Aluminium alloys for naval structures and missile frame	China 32% Peru 12% Australia 9%	China 45% South Korea 7% India 5%
	Titanium	**1,82**	Yes	Missiles; Aluminium alloys for naval structures and missile frame; Electric motors for propulsion; Rockets; Fuel and oxidizer storage tanks and high -pressure vessel	China 25,4% South Africa 13,1% Australia 12,1%	China 35,3% United States 13,9% South Africa 9,3%

	Material	Score	Part of 2023 EU CRM/SRM list	Main uses in the LCF[19]	Top global producers of raw materials (2023)[20]	Top global producers of processed materials (2023)[21]
Low likelihood of disruption	**Molybdenum**	**1,78**	No	Missiles; Special steels for naval guns; Special steels for radars and missile propulsion	China 38,3% Chile 21,3% United States 15,4%	N/A
	Copper	**1,71**	Strategic raw materials list	Missiles; Aluminium alloys for naval structures and missile frame; Shafts, driving controllable pitch propellers	Chile 28% Peru 12% China 8%	China 38% Chile 10% Japan 6%
	Chromium	**1,70**	No	Missiles; Special steels for naval guns; Special steels for radars and missile propulsion	South Africa 56% Kazakhstan 16% India 12%	South Africa 24% Kazakhstan 14% India 9%
Very low likelihood of disruption	**Gold**	**N/A[22]**	No	Long-range air and surface surveillance radar (D band); Air and surface detection, tracking and guidance radar (I band)	China 12,3% Australia 9,4% Russia 8,6%	N/A

The sections below include analyses for each category of supply disruption likelihood. For a detailed material-specific analysis, see Annex 1.

Materials with high likelihood of supply disruption

Five materials used in the LCF have a high likelihood of supply disruption: gallium, germanium, magnesium, and two types of light rare earth elements (REE), samarium and neodymium. Both gallium and germanium are used in semiconductors, which are key sub-components across defence systems.[23] Gallium is also used in radars and communications systems. Samarium and neodymium are both used in the propulsion of the frigate, as well as in the propulsion of missiles.[24] Magnesium is used in armament – missiles, flares, and incendiary bombs – as well as aluminium alloys.[25]

The main vulnerability associated with these materials is their supply concentration in China. A proportion of 68% of global supplies of samarium and neodymium is sourced in China, as well as 90% of magnesium.[26] Over-reliance on China is problematic not only from a logistical point of view, as facilities can face sudden technical issues or be affected by workers strikes and other forms of domestic instability, but also – and especially – from a geopolitical perspective.

The shortages in Chinese magnesium production in 2021 illustrate the technical challenges brought by over-dependence on one supplier. As some Chinese provinces were struggling to

22 Score not calculated due to diversified supply base. See methodology.

23 Joris Teer and Mattia Bertolini, 'Reaching Breaking Point: The Semiconductor and Critical Raw Material Ecosystem at a Time of Great Power Rivalry' (HCSS, 2023).

24 Claudiu C Pavel and Evangelos Tzimas, 'Raw Materials in the European Defence Industry', *Publications Office of the European Union*, 2016, 126, https://doi.org/10.2790/509931.

25 Pavel and Tzimas.

26 European Commission et al., 'Study on the Critical Raw Materials for the EU 2023 - Final Report'.

meet their emissions reduction targets, energy intensive industries were instructed to temporarily halt operations.[27] Among these were 25 magnesium smelters in Shanxi and Shaanxi, the global hub for magnesium production.[28] This led to decreased magnesium exports from China and forced the European aluminium industry to rely on available inventories. While the issue was addressed on time and European industry could maintain operations, such challenges may affect magnesium supply in the future.

China and the EU are largely economically interdependent and experienced rapid trade growth in the last years despite the lack of China-EU trade and investment treaties.[29] However, concerns around economic coercion and over-dependence have led the EU to engage more actively in (open) strategic autonomy initiatives, aiming to de-risk strategic supply chains from China. According to the Dutch intelligence agency, China is a key trading partner of the Netherlands but also "poses the greatest threat to the Dutch economic security".[30]

The Sino-US trade conflict will continue to strain the EU-China economic relations. Trade restrictions can be used to further foreign policy goals of the Chinese government, and this is already happening. Gallium, germanium and REEs have all been affected by trade legislation since 2023 (see Figure 9).[31] These were tit-for-tat measures following US restrictions on exports of advanced technologies to China. While the export of materials from China has not been physically restricted, the new pieces of legislation have made it more difficult for companies to engage in export. As of August 2023, companies that want to export gallium and germanium from China have to apply for export licenses that can only be granted by the Chinese Ministry of Commerce. As of December 2023, companies exporting REEs and REE technology are required to report their shipment orders for the coming two years.

Diversification options for these materials are expanding, but China will likely remain the largest supplier in the coming years. The main supply chain vulnerability is the processing rather than the extraction of materials. China is the biggest supplier of gallium and germanium. Gallium and germanium are by-products of aluminium and zinc production, so diversification of primary production can be achieved with relative ease. However, processing facilities are mainly located in China. The production of REEs faces similar challenges – even though they are extracted in various locations, their processing is concentrated in China. Australia and the US extract about 9,5% of the global supply of neodymium and samarium, but lack domestic processing capabilities. Both of them send the raw materials to China or Malaysia for processing. Considering the importance of REE magnets not only for clean energy technologies but also defence applications, the US Department of Defence has allocated more than $439 million since 2020 to establish a 'mine-to-magnet' REE supply chain in the US to reduce dependence on foreign suppliers.[32]

27 United States Geological Survey, 'Magnesium Metal', 2022, https://pubs.usgs.gov/periodicals/mcs2022/mcs2022-magnesium-metal.pdf

28 European Aluminium, 'Call on EU Policymakers to Address Imminent Supply Shortage of Chinese Magnesium', 2021, https://european-aluminium.eu/wp-content/uploads/2022/08/2021-09-27-position-paper_impact-of-imminent-short-1.pdf

29 Arendse Huld, 'EU-China Relations: Trade, Investment, and Recent Developments', China Briefing News, 4 April 2023, https://www.china-briefing.com/news/eu-china-relations-trade-investment-and-recent-developments/.

30 Cagan Koc, 'Dutch Say Russia, China Are Biggest Threats to National Security', *Bloomberg.Com*, 17 April 2023, https://www.bloomberg.com/news/articles/2023-04-17/dutch-say-russia-china-are-biggest-threats-to-national-security.

31 Irina Patrahau, Lucia Van geuns, and Tom Draaijer, 'Critical Raw Materials in the Dutch Province of Zuid-Holland: What, Why and How?' (The Hague Centre For Strategic Studies, 2024), https://hcss.nl/report/critical-raw-materials-in-the-dutch-province-of-zuid-holland-what-why-and-how/.

32 C. Todd Lopez, 'DOD Looks to Establish "Mine-to-Magnet" Supply Chain for Rare Earth Materials', U.S. Department of Defense, 2024, https://www.defense.gov/News/News-Stories/Article/Article/3700059/dod-looks-to-establish-mine-to-magnet-supply-chain-for-rare-earth-materials/

Figure 9. Development of trade relations in critical minerals and digital technologies between the US, the Netherlands and China. Figure from Patrahau et al., 2024.

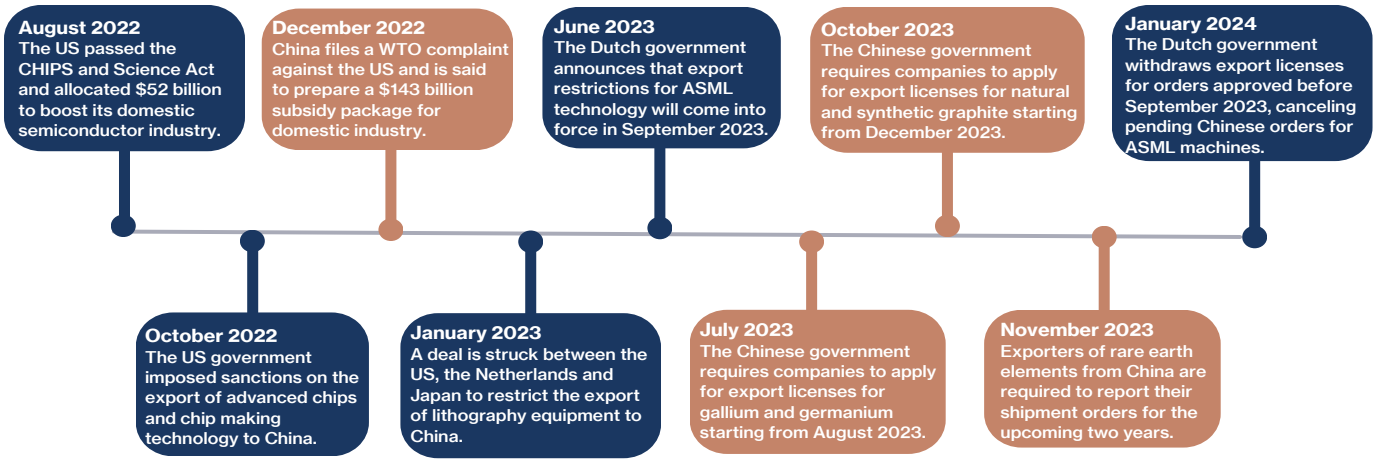
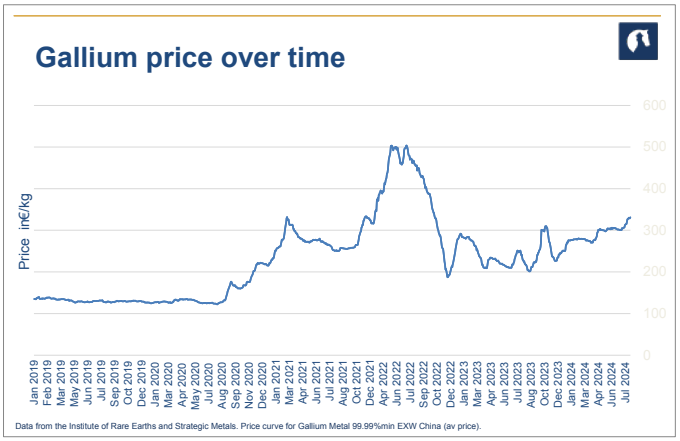
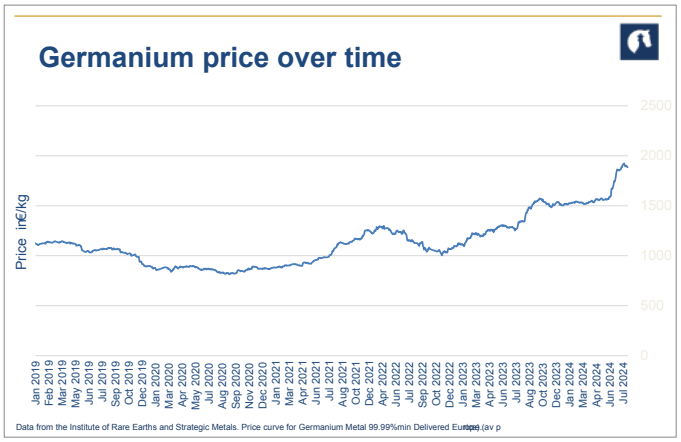
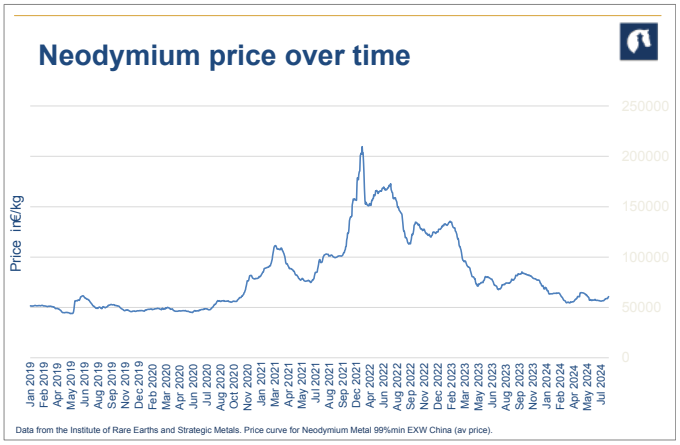
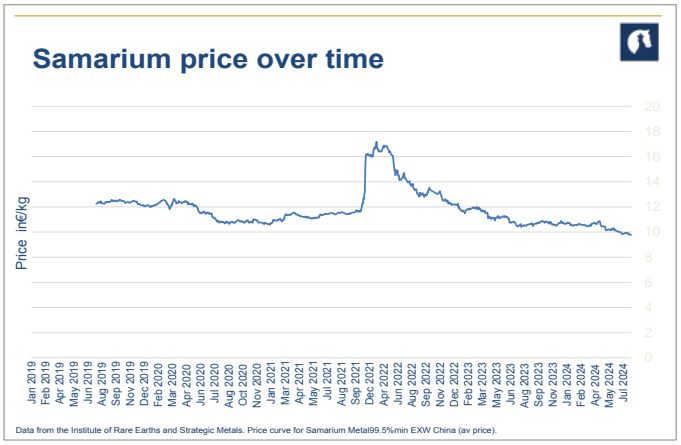


Figure 10. Price developments for gallium, germanium, neodymium and samarium.









The prices of gallium, germanium, neodymium and samarium have been quite volatile over the last few years, increasing the likelihood of a future disruption (Figure 10). The export controls imposed by the US and China since 2022 coincide with spikes in the prices of these materials, showing the vulnerability of global prices to geopolitical events.

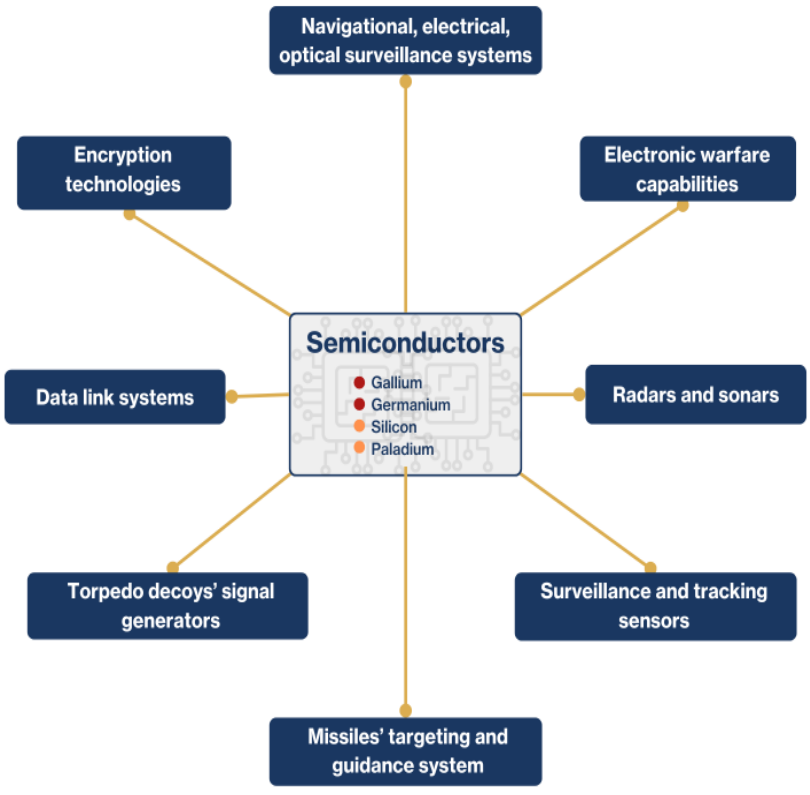
When it comes to material-specific characteristics, four of them are extremely difficult to recycle and substitute. Apart from magnesium that has a 13% end-of-life recycling input rate, the other four have values of under 3%, and even under 1% for REEs in Europe. Finally, substitution is technology-specific, but these materials generally have a low substitution rate, especially for defence applications where high quality and reliable materials are required.

The use of semiconductors in defence applications

Semiconductors play a crucial role in the defence sector, powering a wide array of advanced military technologies. These components are fundamental to the operation of communication systems, radar, and electronic warfare equipment, enhancing the capabilities and effectiveness of defence operations. Semiconductors enable the miniaturization and increased performance of these systems, allowing for more sophisticated and reliable equipment. For instance, in missile guidance systems and satellite technology, semiconductors ensure precision and robustness under extreme conditions. Furthermore, they are vital in the development of unmanned aerial vehicles (UAVs), providing the necessary computational power and sensor integration.

In military vessels such as the LCF, semiconductors can be found in missiles' targeting and guidance system, torpedo decoys' signal generators, radars and sonars, navigational/electrical/optical surveillance systems, surveillance and tracking sensors, data link systems, electronic warfare capabilities, encryption technologies (see This research focuses on the Air Defence & Command Frigate (Luchtverdedigings- en Commandofregat - LCF). The strong focus of the Dutch Defence Industrial Strategy on the maritime domain and the ease of access to information narrowed the search for suitable platforms to the maritime domain, specifically to surface vessels. The desire to look at supply chains of military-specific systems of the chosen platform resulted in the LCF as the case study. The LCF has both offensive and defensive capabilities with a variety of weapon systems, sensors, and communication equipment, and is a vessel with a relatively high share of Dutch designed/made systems on board.).

The defence sector's reliance on semiconductors is set to grow with the advancement of technologies such as artificial intelligence, quantum computing, and cybersecurity, making them indispensable for maintaining national security and technological superiority. While the semiconductor value chain is concentrated in the US, Taiwan, and South Korea, the materials needed for manufacturing these chips originate in more unstable or politically unfriendly countries like China, Russia or the Democratic Republic of Congo, increasing supply chain vulnerability.



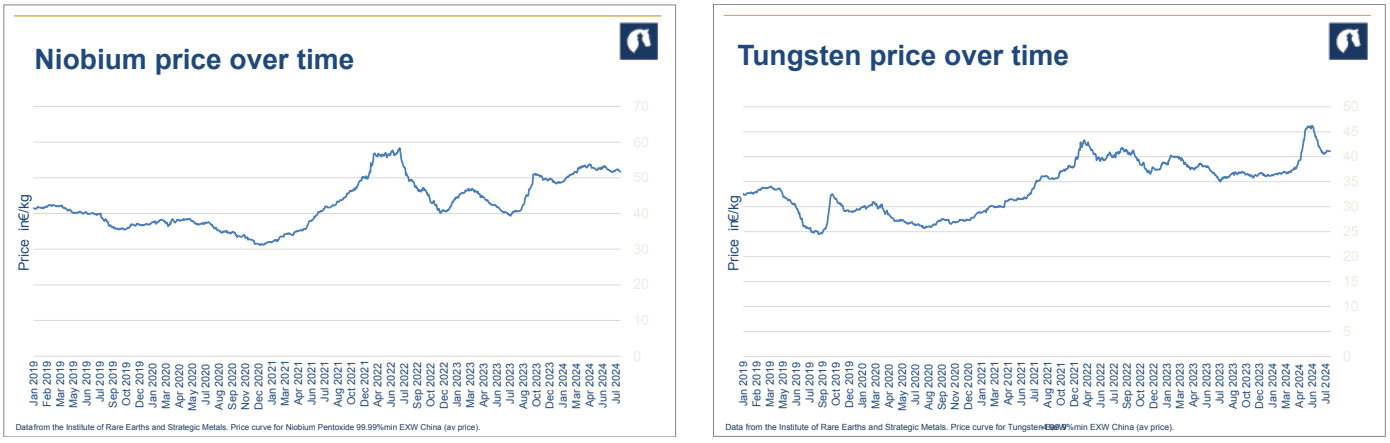
References: Joris Teer, Mattia Bertolini, and Benedetta Girardi, 'Competitie Tussen Grootmachten En Maatschappelijke Stabiliteit in Nederland: De Risico's van Russisch Gas, Chinese Grondstoffen En Taiwanese Chips Voor Vitale Sectoren' (The Hague Centre For Strategic Studies, 2023), ; Sujai Shivakumar and Charles Wessner, 'Semiconductors and National Defense: What Are the Stakes?' (CSIS, 6 August 2022), ; John Dyson, 'How Semiconductors Are Enhancing National Security Advantage', Karve International, accessed 26 July 2024.

Materials with medium likelihood of supply disruption

Thirteen materials have a medium likelihood of supply disruption. Silicon metal and palladium are essential for semiconductors.[33] Silicon metal is also used to produce aluminium alloys like series 6061 and series 6082 for naval structures and missile frames, together with manganese and aluminium.[34] Tungsten, silicon metal, niobium, aluminium, manganese, tantalum and lithium are used in missiles.[35] Silver and beryllium are used in communication systems.[36] Aluminium is also necessary for radars, while borates for missiles.[37]

Tungsten and niobium have a strongly concentrated supply base in China (approx. 83% of global tungsten supply at extraction level) and Brazil (approx. 92% of global niobium supply).[38] The prices of these materials have been on the rise since 2019 (Figure 12). Countries like Vietnam and the US with whom the Netherlands/EU have relatively good relations have some production facilities for tungsten too, lowering the likelihood of disruption. Vietnam is responsible for 6,4% of tungsten extraction, while the US processes 4,4% of tungsten.[39] In addition, tungsten has a 42% end-of-life recycling input rate in the EU, further reducing the risks.[40] When it comes to niobium, the relationship between the EU and Brazil is the main indicator for disruption. Brazil is one of the four Mercosur countries involved in the trade agreement with the EU which is in its final stages of ratification.[41] Despite this, Brazil has a relatively high risk of internal instability and political relations with the Netherlands and the EU vary significantly depending on the political leadership.[42]

Figure 12. Price developments for niobium and tungsten



33 Teer and Bertolini, 'Reaching Breaking Point: The Semiconductor and Critical Raw Material Ecosystem at a Time of Great Power Rivalry'.

34 Pavel and Tzimas, 'Raw Materials in the European Defence Industry'.

35 Pavel and Tzimas.

36 Pavel and Tzimas.

37 Pavel and Tzimas.

38 European Commission et al., 'Study on the Critical Raw Materials for the EU 2023 - Final Report'.

39 European Commission et al.

40 European Commission et al.

41 'EU-Mercosur Joint Press Statement', European Commission, 2023, https://policy.trade.ec.europa.eu/news/eu-mercosur-joint-press-statement-2023-12-07_en.

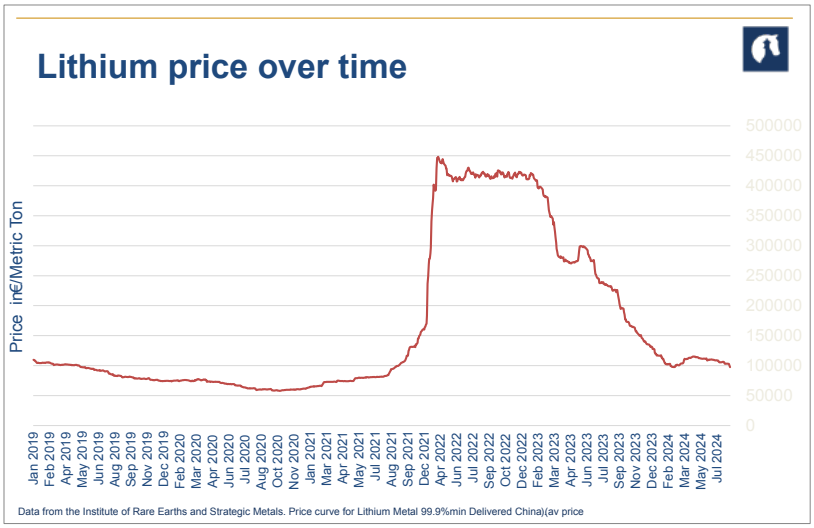
42 'Global Data', Fragile States Index, 2024, https://fragilestatesindex.org/global-data/; Sofia Moutinho, 'After Lula's Win, "a Huge Relief!"', *Science* 378, no. 6619 (2022): 464–464, https://doi.org/10.1126/science.adf6054.

The global production of borate is concentrated in Türkiye, both at the extraction and processing stages (48,4% and 44,4%, respectively). The EU is highly dependent on Türkiye for most of its imports, with limited opportunities for increasing domestic production capabilities. A potential source for diversification is in Serbia's Jadar lithium-borate mine, which has been undergoing significant difficulties in terms of political and public opposition.

Except for tungsten, niobium and borate, the supply base of most materials is quite diversified. They tend to be produced (1) in likeminded countries like Australia, but in relatively small proportions compared to other producers; (2) in countries that struggle with domestic instability, like Guinea, the DRC, or Kazakhstan; (3) in countries that have a complex geopolitical position, like the US, South Africa, China and Russia.

Reliable likeminded countries like Australia or Canada have been making significant investments in their own mineral industries to become trusted global suppliers and reduce import dependence. Australia supplies 28% of global bauxite, but this is often sent to China to be produced into aluminium, with 56% of global production.[43] Aluminium has a relatively high recycling input rate of 32% in Europe but it remains difficult to substitute.[44] Australia is also the largest producer of lithium in the world, with 53% share, followed by Chile with 24%.[45] Still, China dominates the lithium processing market, accounting for 56% of the global market share. Lithium has a very low end-of-life recycling input rate in Europe and is difficult to substitute.[46] Lithium prices spiked in 2022 due to the globally high demand for electric vehicles, but have been steadily decreasing throughout 2023-2024 (Figure 13). This is causing significant issues for the business case of European companies that started making investments in lithium facilities. Finally, Canada supplies 10% of palladium, but that is balanced out by the Russian dominance in the value chain, responsible for 40% of processing in the world.[47] As such, diversification options, albeit limited, do exist.

Figure 13. Price development for lithium



43 European Commission et al., 'Study on the Critical Raw Materials for the EU 2023 - Final Report'.
44 European Commission et al.
45 European Commission et al.
46 European Commission et al.
47 European Commission et al.

Countries whose domestic instability threatens to interfere with the output of the extraction and processing facilities are responsible for a notable share of mineral supply as well. Tantalum supply is shared between the DRC with 35%, Rwanda with 17% and Brazil with almost 16%. Since 2023, the EU has signed Memoranda of Understanding (MoU) with both the DRC and Rwanda for enhanced cooperation around raw materials.[48] Still, the two countries are institutionally unstable, increasing the chance that a supply chain disruption might occur.[49]

Mexico and Peru are the top global producers of silver, with 24% and 14% of the global share, respectively. Silver is difficult to substitute as well as having a recycling input rate of only 4% in the EU.[50] The two countries have positive relations with the Netherlands and the EU, but they have a high domestic instability risk. The EU has had a free trade agreement with Peru since 2013 and is the largest foreign investor in the country. The EU and Mexico concluded negotiations for a new trade agreement in 2020.[51] Additionally, both Peru and Mexico are part of the 2023 EU-Latin America and the Caribbean Global Gateway Investment Agenda, which encompasses planned investments in the pillars of a just green transition, an inclusive digital transformation, human development and health resilience.[52] Still, in December 2022, protests and violent clashes killing over 60 people took place in Peru, as a consequence of President Castillo's self-coup attempt.[53] The protests primarily took place in the southern regions, which also host the mining sector, leading to disruptions of labour and transport. While Mexico's political stability improved significantly in the last two decades, economic slow-down and rise in organised crime threaten the progress.[54]

The EU is also import-dependent on countries with complex positions in global politics like the US and South Africa. The US is the main supplier of silicon, with 41% of production at extraction level. While China controls 76% of processing, this material is unlikely to be used in the semiconductor industry as its purity levels are not high enough.[55] Rather, the silicon made in China is more often used for solar panels in the energy industry. The US is also the main producer of beryllium, both in the extraction and processing stages, with 67,3% and 50,2% global market share, respectively.[56] While the relationship between the US and the Netherlands has always been very strong in political, economic and military terms, the US has been a volatile partner for Europe in the last decade. Its strategic shift from Europe to the Indo-Pacific and increasingly aggressive use of economic sanctions raise the likelihood of a potential disruption in supply.

48 'EU Signs Strategic Partnerships with DRC and Zambia', European Commission, 2023, https://ec.europa.eu/commission/presscorner/detail/en/ip_23_5303; 'EU and Rwanda Sign a Memorandum of Understanding', European Commission, 2024, https://ec.europa.eu/commission/presscorner/detail/en/ip_24_822.

49 'Global Data'.

50 European Commission et al., 'Study on the Critical Raw Materials for the EU 2023 - Final Report'.

51 'The European Union and Peru', Delegation of the European Union to Peru, 2021, https://www.eeas.europa.eu/peru/european-union-and-peru_en?s=162; 'EU-Mexico Trade Agreement', European Commission, 2020, https://ec.europa.eu/commission/presscorner/detail/en/ip_20_756.

52 Directorate-General for International Partnerships, 'EU-LAC Global Gateway Investment Agenda', European Commission, 2023, https://international-partnerships.ec.europa.eu/publications/eu-lac-global-gateway-investment-agenda-infographics_en.

53 Martin Cassinelli, 'Peru's Recession Should Be a Wake-up Call for Its Politicians', *Atlantic Council* (blog), 24 August 2023, https://www.atlanticcouncil.org/blogs/new-atlanticist/perus-recession-should-be-a-wake-up-call-for-its-politicians/.

54 Avery Ruxer Franklin, 'Report Predicts Mexico's Economy, Politics Will Deteriorate in 2023', Rice University, 2023, https://news.rice.edu/news/2023/report-predicts-mexicos-economy-politics-will-deteriorate-2023; Gabriel Farfan-Mares, 'Prospects for Democracy in Mexico: A Public Finance Perspective', 2022, https://www.wilsoncenter.org/article/prospects-democracy-mexico-public-finance-perspective.

55 Teer and Bertolini, 'Reaching Breaking Point: The Semiconductor and Critical Raw Material Ecosystem at a Time of Great Power Rivalry'.

56 European Commission et al., 'Study on the Critical Raw Materials for the EU 2023 - Final Report'.

South Africa is the largest global producer of manganese at extraction level, with 29,3% of global share, though this is sent to China for processing. The country is also a key palladium supplier controlling about one third of total production, though Russia is the highest supplier with 40% of the market. South Africa also produces about 10% of global vanadium at both extraction and processing levels, but once again China and Russia are more dominant, controlling 61,6% and 19,8% respective shares. South Africa has overall positive relations with the Netherlands and the EU, though its political leadership has been strengthening ties with Russia and China over time, making it a complex partner. The country is closely cooperating with non-Western states and is a member of the BRICS as well as the Non-Aligned Movement.[57] In international fora, the voting patterns are frequently more closely aligned with developing countries.[58]

Materials with low likelihood of supply disruption

Ten materials have been assessed to have a relatively low likelihood of supply disruption compared to the others. A notable portion of these are used in missiles: lead, zirconium, cobalt, borate, titanium, molybdenum, chromium, copper.[59] The other main use of these materials is the production of special steels CLARM HB7 for naval guns (steel, molybdenum & chromium) and APX4 for radars and missile propulsion (steel, nickel, molybdenum, chromium).[60] When it comes to propulsion, electric motors use lead, titanium and cobalt; and shafts & driving controllable pitch propellers use nickel and copper.[61] Titanium is also used in rocket manufacturing.[62]

Apart from cobalt, borate and titanium metal, which are included in the EU's CRM list, the other materials tend to have lower supply risks and therefore are not part of the list. Nickel and copper are on the EU's SRM list. According to the EU's criticality methodology, they do not qualify as critical, but they are nonetheless essential for strategic technologies.

Cobalt has a relatively concentrated supply base, but reliable suppliers have production capacity as well thus bringing down the likelihood of disruption. Cobalt is extracted primarily in the DRC but processed in China.[63] Yet Finland and Belgium are also important suppliers of processed cobalt, with 11,4% and 5,3% market shares, respectively. Cobalt has a relatively high end-of-life recycling input rate of 22% in the EU, lowering the likelihood of disruption.[64]

Titanium metal is an essential material for the defence industry, very difficult to substitute or recycle. Even though it is on the EU's CRM list, it has quite a diversified supply base, despite China being the market leader. South Africa and Australia are extracting countries, with 13,1% and 12,1% of the global supply. The US and Australia are active in titanium processing, with 13,9% and 9,3% respective market shares.

57 'International Relations', South African Government, accessed 15 November 2023, https://www.gov.za/about-sa/international-relations.

58 Len Ishmael, 'Alliances in a Shifting Global Order: South Africa', German Marshall Fund of the United States, 2023, https://www.gmfus.org/news/new-geopolitics-alliances-rethinking-transatlantic-engagement-global-swing-states/south-africa.

59 Pavel and Tzimas, 'Raw Materials in the European Defence Industry'.

60 Pavel and Tzimas.

61 Pavel and Tzimas.

62 Chin Trento, 'Six Strategic Metals Widely Used in the Military Industry', Stanford Advanced Materials, accessed 25 July 2024, https://www.samaterials.com/content/six-strategic-metals-widely-used-in-the-military-industry.html.

63 European Commission et al., 'Study on the Critical Raw Materials for the EU 2023 - Final Report'.

64 European Commission et al.

Indonesia is the leading nickel supplier in the extraction process, while China dominates nickel processing. In the coming years, this balance may shift in Indonesia's favour. In 2020, Indonesia implemented a "*downstreaming*" strategy to bolster its domestic processing industry.[65] This also entailed the ban of raw nickel exports. Due to foreign investments and increasing demand for electric vehicles, new mining and processing developments in Indonesia have driven significant growth in the global nickel industry in recent years. Yet as a result of substantial Chinese investments in the Indonesian nickel industry, China has increased its influence in the nickel sector as well.[66]

Copper is a base metal, like iron, nickel and zinc, meaning that it is very abundant in the Earth's crust and many countries have historical legacies for mining it. South American countries Chile and Peru are the top producers of copper, with 28% and 12% shares in its global extraction. Due to its importance in all electricity infrastructure and equipment, copper has been placed on the list of strategic raw materials. It has a very high recycling input rate of 55% in Europe and a diversified supply base, meaning that the chance of disruption is relatively low, but this is likely to change in the future.

Zinc and iron are raw materials produced in very large quantities all over the world, though China controls the majority of production. While a lot of iron is mined in Australia (37% of total production), 52% of the global supply is produced into steel in China. Steel is the main component of special steels in the defence industry, used across many different applications. The zinc production is also dominated by China, though countries like Peru, Australia, South Korea and India have a role to play along the supply chain as well.

Lead and molybdenum are both used in missiles, in addition to electric motors for lead, and special steels for molybdenum. Both materials are primarily sourced in China, which dominates 43% of lead processing and 38,3% of molybdenum processing. Lead suffers from supply concentration considering that the second largest supplier of processed lead is the US with 9,5% of global supply. Molybdenum, contrastingly, has a more diversified supply base with Chile and the US controlling 21,3% and 15,4% of global shares, respectively.

Finally, chromium and zirconium are at relatively low risk due to the diversified supply base and overall positive relations between the Netherlands and the EU, and these suppliers. Chromium is produced in South Africa, Kazakhstan and India, which are complex partners to the EU but relatively reliable. Chromium also has a high recyclability rate of 21%. Zirconium is extracted in Australia, South Africa and Mozambique, which are once again countries with good relations with the Netherlands and the EU.

Materials with very low likelihood of supply disruption

Gold is the outlier to the analysis. While still an important material used in several defence applications, its top three suppliers (China, Australia, and Russia) control only about 30% of global production. While the relations between the Netherlands and China and Russia are multifaceted and complicated by Sino-American competition and the Russian aggression on Ukraine, the high diversification opportunities for gold make the likelihood of disruptions very low.

65 Ilija Bozovic, 'Hoe de Indonesische Bevolking Lijdt Onder de Elektrische Auto', VPRO Tegenlicht, 2024, https://www.vpro.nl/programmas/tegenlicht/lees/artikelen/2024/nieuwsverhalen/hoe-de-indonesische-bevolking-lijdt-onder-de-elektrische-auto.html.

66 Angela Tritto, 'How Indonesia Used Chinese Industrial Investments to Turn Nickel into the New Gold', Carnegie Endowment for International Peace, 2023, https://carnegieendowment.org/research/2023/04/how-indonesia-used-chinese-industrial-investments-to-turn-nickel-into-the-new-gold?lang=en&center=global.

4.2. **Systems & Components**

The Netherlands' dependencies and vulnerabilities on foreign actors are not only limited to the CRM used in defence components. While the LCF is assembled by Damen in the Netherlands, many of the critical components are imported from other countries (see Table 12). As the information about lower tier suppliers remains scarce, this section focuses on tier-1 suppliers of systems and components for the LCF, all of which are NATO allies. It provides an overview of the Netherlands' relations with suppliers of components deemed critical for a military ship. The goal of the section is to highlight the position of the Netherlands vis-a-vis its components' manufacturers when it comes to security, military, and economic relations. Close, long-standing ties between two countries are likely to lead to a steady supply, while delicate, unbalanced relations could hamper the procurement of critical components.

The analysis reveals that the Netherlands' procurement of critical components for the LCF is supported by strong and multifaceted relationships with key partner countries, including Finland, France, Germany, Italy, Norway, the United Kingdom (UK), and the US (see Table 12). These partnerships are underpinned by robust economic, military, and political ties, often framed within broader EU and NATO initiatives. While the Dutch-Finnish, Dutch-German, and Dutch-Norwegian relationships exhibit stable and cooperative dynamics, the Dutch-French and Dutch-Italian relations are more complex, particularly with France's recent protectionist tendencies. However, these complexities are not likely to significantly impact defence cooperation. The Dutch-US relationship, although historically strong, faces potential uncertainties due to protectionist policies and political developments. The overall security cooperation landscape remains resilient, with a continued focus on joint exercises, strategic alignments, and mutual contributions to European and global security initiatives. Regardless, Dutch policymakers should remain vigilant to evolving geopolitical conditions, particularly concerning US policy shifts and potential tensions with Russia, to ensure the uninterrupted supply of critical components for the LCF.

Table 12. Countries of origin of manufacturers of systems in the LCF

C2I support	NL
Navigation	NL
Self Defence	NL, FR, US
ASW	DE
ASuW	NL, NOR, IT, US
Armament	NOR, US
Propulsion	FIN, DE, UK

Finland

Finland is a key manufacturer of components used in the propulsion of the LCF. Dutch-Finnish relations are marked by a robust and multi-faceted engagement embedded within the broader frameworks of the EU and NATO.[67]

The two countries cooperate in the field of defence through joint exercises, strategic alignments, and shared contributions to European and global security initiatives. For instance, the Netherlands and Finland are both active participants in the European Intervention Initiative (EI2), which aims to foster a joint strategic culture and provides a platform for non-binding provisions of military capabilities and forces when necessary for European security matters.[68] The two states have also recently cooperated in the Arctic Challenge Exercise, co-hosted by Norway, Finland, and Sweden, focusing on Arctic and sub-Arctic air operations.[69]

Finland and the Netherlands have robust trade ties, with Dutch exports to Finland including machinery, electronics, and pharmaceuticals, and Finnish exports to the Netherlands comprising machinery, paper products, and chemicals.[70] The two countries also work together on projects related to EU initiatives, operating under the frameworks of the EU Green Deal, Horizon Europe, the European Defence Fund, and PESCO.[71]

There is little-to-no reason to fear a disruption of the supply of critical components for the LCF manufactured in Finland. The relations between Finland and the Netherlands are mainly developed in the broader contexts of EU and NATO initiatives, but their collaboration is strong.

Nonetheless, Dutch policymakers should pay close attention to Finland's security position, after its recent joining of NATO. Finland has an extensive border with Russia, which augments instability given the status of current relations between Europe and Russia. Finland's investment in interoperable defence systems will increase demand for components, which may impact defence procurement in the rest of Europe in the short term, including the Netherlands.[72]

67 'Finland', Kingdom of the Netherlands, 2024, https://www.netherlandsandyou.nl/web/finland.

68 Clément Nicolas, 'Finland Becomes Tenth Participant Country in European Intervention Initiative', Euractiv, 9 November 2018, https://www.euractiv.com/section/defence-and-security/news/finland-becomes-tenth-country-to-join-the-european-intervention-initiative/.

69 'Arctic Challenge Exercise 23', Finnish Air Force, 2023, https://ilmavoimat.fi/en/ace23-en.

70 'EU Trade', European Commission, 18 July 2024, https://policy.trade.ec.europa.eu/index_en.

71 'Communication From The Commission To The European Parliament, The European Council, The Council, The European Economic And Social Committee And The Committee Of The Regions - The Green Deal' (European Commission, 11 December 2019); 'List of Participating Countries in Horizon Europe', European Commission, 2021, https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/common/guidance/list-3rd-country-participation_horizon-euratom_en.pdf; PESCO, 'Permanent Structured Cooperation (PESCO's) Projects - Overview', 2018, https://www.consilium.europa.eu/media/41333/pesco-projects-12-nov-2019.pdf.

72 Anne Kauranen and Andrew Gray, 'Finland Joins NATO in Historic Shift, Russia Threatens "Counter-Measures"', *Reuters*, 4 April 2023, sec. Europe, https://www.reuters.com/world/europe/finland-set-join-nato-historic-shift-while-sweden-waits-2023-04-04/.

France

As some of the LCF components, especially in the domain of self-defence, are manufactured in France, it is important to take a closer look at the two countries' relations, which have been steady for the past few decades.

Dutch-French cooperation in the military domain is strong, as the two countries cooperate in numerous venues to increase interoperability and collective defence capabilities. Instances of cooperation include the Joint Expeditionary Force (JEF), NATO's Exercise Trident Juncture, and the Frisian Flag exercise.[73]

Economically, France and the Netherlands have a dynamic trade relationship, with the Netherlands exporting high-value goods like electronics, machinery, and agricultural products, while France exports automobiles, luxury goods, and pharmaceuticals. Investment flows are equally robust, with Dutch enterprises investing in French aerospace, green technology, and digital innovation sectors, and French firms focusing on Dutch infrastructure, finance, and agribusiness.[74] Dutch-French cooperation is also strong in the sectors of emerging technologies such as quantum and AI.[75]

Politically, relations between France and the Netherlands are strengthened by the two countries' advocacy for strategic autonomy, particularly in critical sectors like energy, technology, and healthcare.[76]

However, against the backdrop of the Russian aggression on Ukraine, France has taken an increasing protectionist turn when it comes to its defence industry. In March 2023, French representatives in the European Parliament argued against the inclusion of non-EU members as beneficiaries of the funds under the European Defence Industry Reinforcement Through Common Procurement Act. This move was seen by many as a power grab for France.[77] Additionally, the French government has recently supported over twenty relocation projects of companies and direct suppliers of the Ministry of Armed Forces. Most notable is the relocation of Eurenco, the European leader in powders and explosives, from Sweden, Germany and Italy to the south of France.[78] This move is quite symbolic, as France has good relations with Sweden, Germany, and Italy, but still decided to relocate the production of explosives and powders.

Despite these developments, it is worth noting that no measure has been applied insofar to specific components or manufacturers. Additionally, most of France's initiatives still point towards openness of the defence market to EU member states.

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73 'The Joint Expeditionary Force (JEF)', JEF, 19 July 2024, https://jefnations.org/; NATO, 'Exercise Trident Juncture 2018', NATO, 2018, https://www.nato.int/cps/en/natohq/157833.htm; AfterDark Media, 'Exercise Report - Frisian Flag 2022', Aviamagazine.com, 2018, http://www.aviamagazine.com/reports/exercise/2022/FrisianFlag/index.aspx.

74 'The Observatory of Economic Complexity | OEC', OEC - The Observatory of Economic Complexity, accessed 18 January 2023, https://oec.world/.

75 'Joint declaration – Government Consultations Netherlands - France', diplomatieke_verklaring, Government.nl (Ministerie van Algemene Zaken, 12 April 2023), https://www.government.nl/documents/diplomatic-statements/2023/04/12/joint-declaration---government-consultations-netherlands---france-12-april-2023.

76 'Joint declaration – Government Consultations Netherlands - France'.

77 Suzanne Lynch, Eddy Wax, and Jacopo Barigazzi, 'France Pushes Protectionism in Ukraine Defense Plan', POLITICO, 13 March 2023, https://www.politico.eu/article/eu-defense-ukraine-plan-france-protectionism-arms-production-edirpa-procurement/.

78 Jean-Michel Bezat and Veronique Malecot, 'How the French Arms Industry Is Scaling Up', *Le Monde.Fr*, 20 April 2024, https://www.lemonde.fr/en/economy/article/2024/04/20/how-the-french-arms-industry-is-scaling-up_6668967_19.html.

Germany

The LCF depends on German components when it comes to its anti-submarine warfare and propulsion capabilities.

Germany and the Netherlands are strong partners and have solid military, economic, and political relations. As neighbouring countries with similar political landscapes, they frequently coordinate their positions on various European and global issues, including climate change, innovation, and economic governance.[79] Military and security cooperation between the Netherlands and Germany is characterised by deep integration and collaboration within NATO and the European Union's Common Security and Defence Policy (CSDP).[80] The two nations participate in joint military exercises, training programs, and defence initiatives, enhancing their operational interoperability.[81] A notable example is the integration of a Dutch army brigade into a German division, showcasing a significant level of military cooperation.[82] This partnership extends to intelligence sharing and counter-terrorism efforts, addressing common security challenges such as cyber threats and regional instability. The Netherlands and Germany also collaborate on defence procurement, jointly investing in advanced military technology and infrastructure.[83]

The economic relationship between the Netherlands and Germany is robust and mutually beneficial, driven by significant trade and investment ties. The Netherlands is the second largest foreign supplier of goods to Germany and the fourth largest destination for German goods exports.[84] Dutch exports consist particularly in machinery, chemicals, and food products. Conversely, the Netherlands is a key market for German goods, including automobiles and industrial machinery.[85] Cross-border investments are also notable, with numerous Dutch and German companies operating in each other's markets, further cementing their economic interdependence.[86]

The robustness of Dutch-German relations, as well as the general alignment of the two neighbours on security, economic, and political issues is reassuring. Furthermore, the notable steps undertaken by the two countries toward integration and interoperability of military capabilities makes it difficult to forecast disruptions to procurement.

79 Auswärtiges Amt, 'Germany and the Netherlands: Bilateral Relations', German Federal Foreign Office, 2024, https://www.auswaertiges-amt.de/en/aussenpolitik/laenderinformationen/niederlande-node/germany-netherlands-bilateral/227968.

80 Ministerie van Algemene Zaken, 'Joint declaration – Government Consultations Netherlands - Germany', diplomatieke_verklaring, Government of the Netherlands (Ministerie van Algemene Zaken, 27 March 2023), https://www.government.nl/documents/diplomatic-statements/2023/03/27/joint-declaration---government-consultations-netherlands---germany-27-march-2023; Dick Zandee and Davis Ellison, 'Germany's Zeitenwende and the Consequences for German-Dutch Defence Cooperation', n.d.

81 Zandee and Ellison, 'Germany's Zeitenwende and the Consequences for German-Dutch Defence Cooperation'.

82 Ministerie van Defensie, '13 Light Armoured Brigade Completes Integration between Dutch Combat Brigades and German Divisions - News Item - Defensie.NI', nieuwsbericht (Ministerie van Defensie, 30 March 2023), https://english.defensie.nl/latest/news/2023/03/30/13-light-armoured-brigade-completes-integration-between-dutch-combat-brigades-and-german-divisions.

83 Zandee and Ellison, 'Germany's Zeitenwende and the Consequences for German-Dutch Defence Cooperation'.

84 'Executive Summary - Duitsland - Internationaliseringsmonitor', CBS, Executive Summary - Duitsland - Internationaliseringsmonitor | CBS, 2021, https://longreads.cbs.nl/im2020-1//executive-summary.

85 'The Observatory of Economic Complexity | OEC'.

86 'Executive Summary - Duitsland - Internationaliseringsmonitor'.

Italy

As the LCF depends on Italian components for some of its anti-surface warfare systems, it is important to look at the military, economic, and political relations between the two EU member states. In the realm of military and security, the Netherlands and Italy collaborate closely within the framework of NATO and the EU's CSDP. The two contribute to various NATO missions and EU security initiatives, taking part in joint exercises such as NATO's exercises Trident Juncture, Steadfast Jazz, Dynamic Manta, and Brilliant Jump.[87]

The Netherlands and Italy maintain a robust economic relationship, as highlighted by significant trade exchanges and investment flows. The Netherlands serves as a key gateway for Italian goods entering Northern Europe, with major exports including machinery, pharmaceuticals, and food products. Italy exports automobiles, fashion, and luxury goods to the Dutch market.[88] In 2023, Italy exported goods worth approximately €20.5 billion to the Netherlands, with the Netherlands' total exports to Italy valued at approximately €25.5 billion.[89]

While the relations between the Netherlands and Italy are overall solid, there are some points of contention between policymakers of the two countries, especially when it comes to fiscal discipline and budget deficits.[90] However, such political-economic disagreements are unlikely to affect military procurement. Even with the advent of the more conservative, inward-looking government of Giorgia Meloni, security and defence cooperation is set to remain stable, with the new government posing the accent on reinforcing the country's defence industrial policy and production.[91]

Norway

Dutch-Norwegian relations are characterised by a high degree of cooperation and closeness across various domains. Both countries benefit from their strong partnership, which is built on shared values, mutual interests, and a commitment to addressing global challenges such as climate change and energy shortages.[92] The Netherlands and Norway are involved in multiple military initiatives, including the Northern Group, the European Intervention Initiative, and the Joint Expeditionary Force, which enhance cooperation through knowledge sharing, joint exercises, and strategic culture development. Notably, their collaboration extends to various joint military exercises such as Cold Response 22, Joint Viking 23, and Arctic Challenge 23.[93] The Netherlands' Defence Vision 2035 further outlines a commitment to deepening cooperation with the Northern group, including Norway, particularly in maritime security,

87 'NATO Exercises', NATO, 2024, https://www.nato.int/cps/en/natohq/topics_49285.htm.

88 'The Observatory of Economic Complexity | OEC'.

89 Statistics Netherlands, 'Trade Relations with Italy', webpagina, CBS, 23 March 2020, https://www.cbs.nl/en-gb/background/2020/12/trade-relations-with-italy.

90 'Criticism of Italian Fiscal Policy: Outdated and Unfounded', Instituut voor Publieke Economie, 27 February 2023, https://www.instituut-pe.nl/highlights/italianfiscalpolicy.

91 Alessandro Marrone, 'The Defence Policy of Giorgia Meloni's Government', Text, IAI Istituto Affari Internazionali, 21 November 2022, https://www.iai.it/en/pubblicazioni/defence-policy-giorgia-melonis-government.

92 'Memorandum of Understanding to Promote Bilateral Cooperation in the Field of Carbon Capture and Storage (CCS), and Exploring Future Areas of Energy Cooperation Related to the North Sea', Ministry of Petroleum and Energy of the Kingdom of Norway, accessed 23 July 2024, https://www.regjeringen.no/contentassets/4d3db439c11748c3be985a5b357eedf6/final_memorandum-of-understanding_ccs_nl-and-no.pdf.

93 'Defence - Norway', Kingdom of the Nethelrands, 2024, https://www.netherlandsandyou.nl/web/norway/themes/defence.

intelligence sharing, and space exploration.[94] This is on top of already ongoing cooperation with Norway, for example on project MilSpace2, established by the Dutch Ministry of Defence, the Norwegian Ministry of Defence and a variety of research organisations which jointly launched nanosatellites in 2023.[95] Such initiatives underline the strength of the security cooperation with Norway for the achievement of Dutch security aims.

Economically, Norway's integration into the EU single market through the EEA Agreement facilitates strong trade relations, making it the EU's sixth-largest trading partner.[96] The bilateral economic cooperation between the Netherlands and Norway is particularly pronounced in the energy sector due to significant imports of petroleum, coal, and natural gas.[97] Moreover, the partners have signed a Memorandum of Understanding on the cooperation in the technology development of carbon capture and storage.[98] The Netherlands values Norway as a crucial partner in promoting sustainable mining practices and mitigating environmental risks, especially in the Arctic region.[99]

As political, economic, and security cooperation with Norway is strong, cooperation on the procurement of military systems and components, included the anti-surface warfare and armament capabilities necessary for the LCF attack capabilities, is most likely to proceed undisturbed.

United Kingdom

Components used in the propulsion of the LCF are manufactured by companies based in the UK. The Netherlands and the UK have stable ties marked by cooperation in different fields, among which climate action, emerging security challenges, and energy security.[100]

In the security and defence domain, they mainly cooperate under NATO, participating in joint military exercises and operations, and overall contributing to collective defence initiatives.[101] The bilateral defence cooperation between the two countries has been stable even after Brexit, with the June 2017 joint vision statement by the UK Secretary of State for Defence Sir Michael Fallon and the Dutch Minister of Defence Jeanine Hennis-Plasschaert strengthening

94 'Defence Vision 2035', publicatie, Ministry of Defence of the Kingdom of the Netherlands (Ministerie van Defensie, 15 October 2020), https://doi.org/10/15/defence-vision-2035.

95 'Norwegian-Dutch Nanosatellites Successfully Launched', TNO, accessed 23 July 2024, https://www.tno.nl/en/newsroom/2023/01/norwegian-dutch-nanosatellites/.

96 'EU Trade Relations with Norway', European Commission, 2024, https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/norway_en.

97 'Five northern European countries conclude international arrangements on transport and storage of carbon across borders', nieuwsbericht, Government of the Netherlands (Ministerie van Algemene Zaken, 15 April 2024), https://www.government.nl/latest/news/2024/04/15/five-northern-european-countries-conclude-international-arrange-ments-on-transport-and-storage-of-carbon-across-borders.

98 'Memorandum of Understanding to Promote Bilateral Cooperation in the Field of Carbon Capture and Storage (CCS), and Exploring Future Areas of Energy Cooperation Related to the North Sea'.

99 'The Netherlands' Polar Strategy 2021-2025: Prepared for Change', publicatie, Government of the Netherlands (Ministerie van Algemene Zaken, 1 March 2021), https://www.government.nl/documents/publications/2021/03/01/polar-strategy.

100 'Joint Statement on Foreign, Development and Security Bilateral Cooperation between the United Kingdom of Great Britain and Northern Ireland and the Netherlands', GOV.UK, accessed 24 July 2024, https://www.gov.uk/government/publications/uk-netherlands-strategic-dialogue-2022-joint-statement-on-foreign-development-and-security-bilateral-cooperation/joint-statement-on-foreign-development-and-security-bilateral-cooperation-between-the-united-kingdom-of-great-britain-and-northern-ireland-and-the-ne.

101 'NATO Exercises'.

the ties.[102] More recently, the UK and the Netherlands have confirmed their intention to explore opportunities to develop a future littoral strike platform, adding common capabilities to both nations' Commando Forces.[103]

The economic relationship between the UK and the Netherlands is also robust, underpinned by significant trade and investment flows. The Netherlands is one of the UK's largest trading partners within the European Union, with bilateral trade encompassing a wide range of goods and services.[104] The UK exports machinery, vehicles, pharmaceuticals, and food products to the Netherlands, while it imports machinery, mineral fuels, and electronic equipment from the Dutch.[105]

Given the stability of Dutch-UK ties, there is no significant likelihood that the procurement of critical components to the LCF will be disrupted.

United States

Companies based in the US manufacture components used in anti-surface warfare, self-defence, and armament in the LCF.

Dutch-US relations are characterised by robust military and economic ties. Through NATO, the Netherlands enjoys one of the strongest military relationships with the US, considering Washington as a vital military ally and conducting regular joint exercises.[106] The Netherlands is one of five countries hosting US nuclear weapons outside US territory.[107] The two are aligned in providing military aid to Ukraine and consistently advocate for robust support against Russian aggression.[108] Most importantly, the US is a major source of military capabilities, systems, and components for the Netherlands, which utilises numerous US-built platforms like the F-35 and Patriot air defence systems.[109] The US and the Netherlands also have signed a Chapeau Agreement Establishing a Framework for bilateral Defence Cooperation Activities in 2018.[110]

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102 Captain Wolter Sillevis Smitt and Alexander Willemen, 'The Impact of Brexit on the UK-Netherlands Defence and Security Cooperation' (Militaire Spectator, 2021).

103 'UK and Netherlands Confirm Future Amphibious Relationship', GOV.UK, 2023, https://www.gov.uk/government/news/uk-and-netherlands-confirm-future-amphibious-relationship.

104 Statistics Netherlands, 'Economic Relations with the UK', webpagina, CBS, 22 January 2019, https://www.cbs.nl/en-gb/custom/2018/41/economic-relations-with-the-uk.

105 'The Observatory of Economic Complexity | OEC'.

106 'U.S. Relations With the Netherlands', *United States Department of State* (blog), accessed 23 July 2024, https://www.state.gov/u-s-relations-with-the-netherlands/.

107 Jonathan Masters and Will Merrow, 'Nuclear Weapons in Europe: Mapping U.S. and Russian Deployments | Council on Foreign Relations', Council on Foreign Relations, 30 March 2023, https://www.cfr.org/in-brief/nuclear-weapons-europe-mapping-us-and-russian-deployments;

108 Olena Harmash, 'Dutch Ministers Pledge "rock Solid" Support for Ukraine on First Visit to Kyiv | Reuters', Reuters, 7 July 2024, https://www.reuters.com/world/europe/dutch-ministers-pledge-rock-solid-support-ukraine-first-visit-kyiv-2024-07-07/; Jim Garamone, 'DOD Official Restates Why Supporting Ukraine Is in U.S. Interest', U.S. Department of Defense, 9 February 2024, https://www.defense.gov/News/News-Stories/Article/Article/3671938/dod-official-restates-why-supporting-ukraine-is-in-us-interest/.

109 Stockholm International Peace Research Institute, 'SIPRI Arms Transfers Database', Stockholm International Peace Research Institute, 2021, https://www.sipri.org/databases/armstransfers.

110 'The United States and the Netherlands Sign Defense Agreement', U.S. Embassy and Consulate in the Netherlands, 2 July 2018, https://nl.usembassy.gov/the-united-states-and-the-netherlands-sign-defense-agreement/.

Both countries share liberal market values and, as a member of the EU, the Netherlands cooperates with the US in multilateral economic institutions like the World Trade Organisation and the World Bank.[111] Bilateral trade relations are also strong, with the US exporting $100.7 billion in goods and services to the Netherlands while importing $49.3 billion from the Netherlands in 2022.[112]

While historically strong, ties between the Netherlands and the US have recently appeared more unstable. In the last two years, a series of protectionist policies such as the US Inflation Reduction Act and the Chips and Science Act have raised concerns in the EU about potential adverse impacts on US exports in strategic sectors, illustrating occasional economic policy divergences on themes such as emerging and cutting edge technology.[113] Additionally, US-Dutch discussions over Dutch semiconductor company ASML's exports to China have also created some tensions between the two states.[114]

The future of Dutch-US relations will be influenced by the 2024 US elections, especially in the case of Republican victory, although the pivot to the Indo-Pacific that emerged over the last few years will likely continue regardless of the next administration. A return of the Trump presidency could result in a relationship under increasing pressure in all domains, from trade relations to military ties. However, the extent to which such a stance will result in structural and long-term changes in the relationship is uncertain. Regardless of the next administration, the US has been adopting an increasingly stronger focus toward the Indo-Pacific region, leaving Europe preoccupied with its own security provision.[115]

While the abovementioned trends are unlikely to radically change US-Dutch relations, they should be monitored and taken into account when it comes to procurement of key military components and systems. In fact, while future cooperation will likely continue through NATO, tensions between European and US industries may increase due to political pressures, protectionist measures, and inward-looking foreign policies.

111 'U.S. Relations With the Netherlands'.

112 'Economic Ties - United States', Kingdom of the Nethelrands, 2024, https://www.netherlandsandyou.nl/web/united-states/about-us/economic-ties.

113 Maxime Fajeau et al., 'The US Inflation Reduction Act: How the EU Is Affected and How It Should React', CEPR, 17 October 2023, https://cepr.org/voxeu/columns/us-inflation-reduction-act-how-eu-affected-and-how-it-should-react.

114 'Dutch Lawmakers Question New US Export Restrictions on ASML Chip Machine', *Reuters*, 24 October 2023, sec. Technology, https://www.reuters.com/technology/dutch-lawmakers-question-new-us-export-restrictions-asml-chip-machine-2023-10-24/; Martijn Rasser and Jason Matheny, 'Export Controls Give ASML and the Netherlands an Opportunity to Lead by Example. Will They Take It?' (RAND, 28 November 2022), https://www.rand.org/pubs/commentary/2022/11/export-controls-give-asml-and-the-netherlands-an-opportunity.html.

115 Célia Belin Shapiro Majda Ruge, Jeremy, 'How the 2024 US Presidential Election Could Affect Europe', ECFR, 30 May 2023, https://ecfr.eu/publication/brace-yourself-how-the-2024-us-presidential-election-could-affect-europe/.

5. Policy recommendations and interventions to address geopolitical vulnerabilities in the LCF supply chain

To address geopolitical vulnerabilities in the Dutch defence sector, specifically in the LCF, five high-level recommendations have been developed. These recommendations are based on findings from the supply chain analysis performed in this study and hold for the LCF in particular, where information is particularly scarce. These recommendations can support other military platforms as well, depending on specific needs. Of course platform specific dependencies might result in a different translation of these high-level recommendations into policy interventions.

The 5 high-level recommendations are described below.

1. Enhance awareness, understanding and skills

Availability of information and insights into supply chain vulnerabilities are vital to implement effective policies. Thus, increasing awareness and understanding of defence supply chains should be a priority for Dutch policymakers and the defence industry. At the same time, dealing with supply chain dependencies requires a specific skill set, including scenario building and analysis, and stakeholder engagement and communication.

2. Integrate defence industry in CRM-related activities

The Ministry of Defence and defence industry can reap benefits from broader policies and measures regarding supply chain resilience that are already being taken by/for larger industrial sectors in the Netherlands under the coordination of the Ministry of Economic Affairs. Dialogue on the needs of the Dutch defence industry is necessary to find a proper balance between the industry's needs and the government's possibilities. It can also support alignment with broader European initiatives where parts of the Dutch government are already involved. The Dutch Raw Materials Strategy is under implementation, and actions like integrating defence systems into this strategy can yield notable benefits. Where necessary, developing and implementing defence-specific roadmaps in the context of the National Resource Strategy can be explored further.

3. Improve response to supply chain disruptions

The Ministries of Economic Affairs and Defence should develop a roadmap with the industry, knowledge institutions and relevant governments to improve the resilience and sustainability of the LCF supply chain. This would allow policymakers and the defence industry to improve short-term response, for instance through stress-testing and optimizing inventories, but also take long-term action toward a circular and resilient supply chain. The roadmap could be integrated in the circular manufacturing industry programme of the Ministry of Economic Affairs.

4. Use procurement levers for supply chain resilience

The defence sector is well positioned to address supply chain vulnerabilities through procurement procedures given the relatively concentrated market and unique relationship between industry in the Netherlands, the EU and United States, and Ministry of Defence. Unlike other industries that serve thousands of commercial parties, the defence industry is closely collaborating with a small number of governmental clients. As such, the Ministry of Defence can design procurement procedures to incorporate criteria regarding supply chain resilience and thus push the industry to take steps in this direction. This should be implemented in a progressive way given that fulfilling such requirements takes significant effort from industry and will very likely increase operational costs and product prices.

5. Expand the defence industrial base

Coordination at both the national and international level should be prioritised to ensure a more consolidated and robust defence base. At the national level, collaboration among different ministries, especially Defence and Economic Affairs, is crucial to ensure policy coherence. Furthermore, cooperation with EU and NATO countries should be prioritised as it can support the optimisation of inventories for critical systems, address market fragmentation and overcome national protectionism in the defence sector.

For each of the high-level policy recommendations above, a set of policy interventions has been elaborated. In total, 24 distinct policy interventions were formulated (Figure 14). Each intervention is further classified as: low hanging fruit, high investment high reward, long term incentive, enabler (see section 2 for more information). By choosing to implement a sub-set of these interventions, the Dutch government in collaboration with the EU can strengthen their resilience towards raw materials and component supply disruption with regards to critical defence systems. The interventions are described in the sections below.

Some of the policy interventions have been included in European and national policy documents, often as recommendations but also sometimes are binding recommendations. Notably, the European Critical Raw Materials Act has entered into force in 2024 and imposes requirements around supply chain transparency and stress-testing. Moreover, the European Defence Industrial Strategy recommends moving toward joint procurement and EU-level cooperation to mitigate challenges. Considering that some of the already-presented interventions are not yet being implemented in the Netherlands, they have been reiterated and adapted in this section.

This long-list of interventions was discussed together with the Netherlands' Ministry of Economic Affairs and Ministry of Defence in the context of a SWOT workshop in July 2024. The SWOT analysis is included in Annex 2.

Figure 14. Policy recommendations and types of intervention options

Nr	Policy recommendation	Intervention options					
		1	2	3	4	5	6
1	Enhance awareness, understanding and skills	E	E	E	E		
2	Integrate the defence industry in CRM-related activities				E	E	
3	Improve response to supply chain disruptions			E			
4	Use procurement levers for supply chain resilience	E					
5	Expand the defence industrial base						

Legend

- Low hanging fruit
- High investment high reward
- Long term initiative

E = Enabler

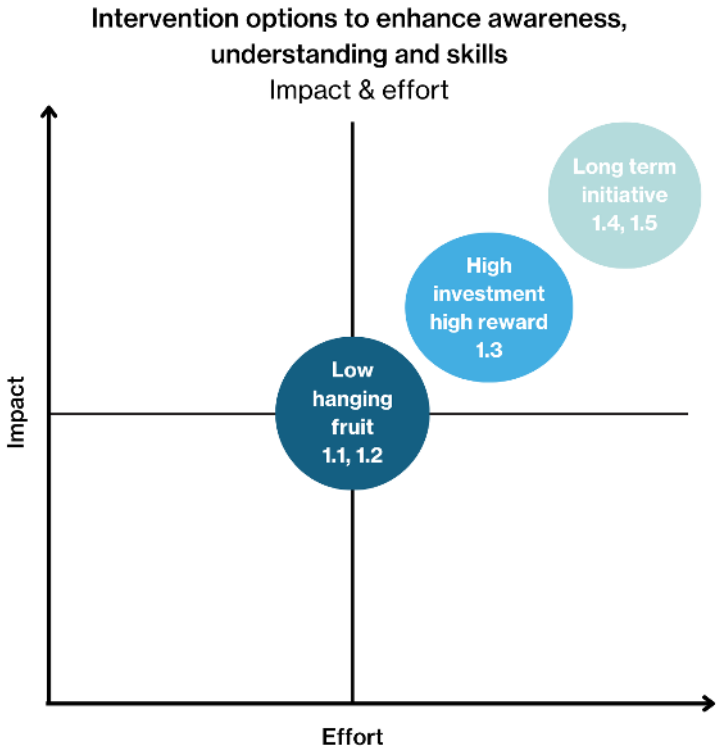
5.1. Enhance awareness, understanding and skills

Knowledge on supply chain dependencies is required for the Ministry of Economic Affairs, Ministry of Defence, and the defence industry to make informed decisions on the subject. Since this knowledge tends to be present within limited sectors of decision-making, broadening awareness and understanding is required. Awareness of supply chain dependencies helps policy makers identify risks and opportunities, but a deeper understanding is needed to develop and implement effective, sustainable and informed policies. At the same time, dealing with supply chain dependencies requires a specific skill set, including scenario building and analysis, and stakeholder engagement and communication. Five policy intervention options were formulated that can strengthen awareness, understanding and skills. They are included in Table 13 below, the qualitative assessment of expected impact and required effort is indicated in Figure 15 and the SWOT analysis is included in Annex 2.

Table 13. Policy intervention options to enhance awareness, understanding and skills

Intervention	Description	Anticipated effect	Responsible entity	Classification
1.1. Enhance awareness and understanding within government of supply chain risks in the defence sector	Depending on their existing level of knowledge, upskill government staff to evolve from unknown unknowns; to known unknowns; to known knowns.	Informed policy making and implementation for CRM dependencies in the defence sector	EZ, MoD	Low hanging fruit, Enabler
1.2. Create dialogue within defence industry on CRM and supply chain risks	Raise awareness among defence industry players that CRM and supply chain security should be prioritised by organising regular meetings, involving them in working groups etc. These dialogues could also encourage the development of joint solutions.	Increased urgency for industry to act	EZ, MoD, EU	Low hanging fruit, Enabler
1.3. Create insights into supply chain for Dutch critical systems manufacturers in the defence sector	Impose requirements on Dutch manufacturers to map their supply chains and identify risks.	Informed policy making and implementation. Strengthened resilience of NLDTIB to CRM disruptions	EZ, MoD, BZK	High investment high reward, Enabler
1.4. Invest in technical know-how for skilled workers in Dutch defence sector	Support the development of (public or private) technical educational programs and trainings for skilled workers in the field of raw materials as well as manufacturing, maintenance and disposal of defence applications.	Increased availability of skilled NL labour force	EZ, MoD, EU	Long term initiative, Enabler
1.5. Invest in CRM alternatives for the defence sector (substitution)	Support research and development of applications with enhanced performance and reduced CRM content.	Reduced CRM dependencies	EZ, MoD, EU, NATO	Long term initiative

Figure 15. Qualitative assessment of expected impact and required effort of interventions to enhance awareness, understanding and skills



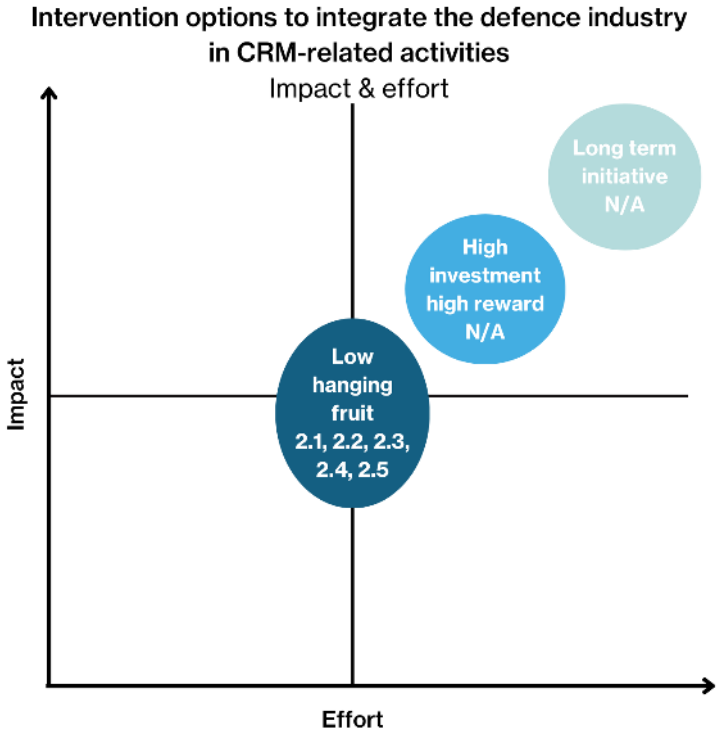
5.2. Integrate the defence industry in CRM-related activities

Ever since the National Raw Materials Strategy was published in December 2022 and the European Critical Raw Materials Act was first introduced in March 2023, there have been significant developments in the European raw materials industry, like the organisation of dialogues between the government and industrial party, the establishment of a National Raw Materials Observatory in the Netherlands, or the engagement – via diplomatic missions – with companies abroad. Given that critical minerals are primarily used in the energy sector, and that the digital sector has been central to geopolitical tensions, the focus has been on these two sectors. Yet, defence is also a sector of critical importance to the national security of the Netherlands and the EU. As such, involving the Ministry of Defence and the defence industry in ongoing activities is a low hanging fruit that can yield good results for supply chain resilience. Concrete policy interventions are shown in Table 14, the qualitative assessment of expected impact and required effort is indicated in Figure 16 and the SWOT analysis is included in Annex 2.

Table 14. Policy intervention options to integrate the defence industry in CRM-related activities

Intervention	Description	Anticipated effect	Responsible entity	Classification
2.1. Involve MoD in policy development around supply chain resilience	Involve MoD and defence industry in relevant national discussions around the implementation of the National Raw Materials Strategy.	Defence perspective incorporated in national CRM policies	MoD, EZ	Low hanging fruit
2.2. Incorporate the interests of MoD and defence industry in Dutch representation in European fora around CRM Act	Incorporate the interests of MoD and defence industry in the Dutch representation in relevant European fora around the implementation of the CRM Act.	Defence perspective incorporated in European CRM policies	EZ, MoD, EU	Low hanging fruit
2.3. Increase defence involvement in existing international CRM agreements and initiatives.	Involve and take into account the needs of the defence industry in international CRM agreements and initiatives outside of the EU/NATO.	Increased security of supply	EU	Low hanging fruit
2.4. Support ongoing domestic/ EU minerals and metals production incentives, including financial or regulatory support.	Leverage initiatives and policies aiming to increase self-sufficiency for CRM for the defence sector.	Lowered regulatory, institutional and financial barriers; Increased support for the competitiveness of EU firms	EZ	Low hanging fruit, Enabler
2.5. Make connections between defence industry, commercial actors and CRM producers in Europe.	Leverage existing initiatives and investments of the civil sector by establishing a presence of the defence sector in strategic fora.	Increased supply security of materials; Increased support for the competitiveness of EU firms	EZ	Low hanging fruit, Enabler

Figure 16. Qualitative assessment of expected impact and required effort of interventions to integrate the defence industry in CRM-related activities



5.3. Improve response to supply chain disruptions

It is essential for the Ministry of Defence and the defence industry to work on contingency planning and stress testing to strengthen resilience to short-term supply disruptions. Improving response capacity is essential to increase awareness and understanding in procurement departments about their supply chains, ways to identify potential causes of disruptions, and strategies to mitigate the impact in a situation characterised by uncertainty and limited information.

Moreover, stockpiling is a common strategy in procurement departments to improve short-term resilience to disruptions, moving from a just-in-time inventory strategy to a just-in-case scenario. There are only a few countries in the world that stockpile raw and processed materials – including the US, Japan, South Korea, China – given the high potential risks associated with this strategy. This strategy may be an option in combination with other vital sectors. Still, for the Dutch defence sector, considering that many components are manufactured abroad and materials may not yield immediate positive results in the case of a disruption, increasing the stockpile of strategic critical components or systems is more beneficial.

Apart from being resilient to short-term disruption, there are notable longer-term initiatives that can bring a structural change to the way in which materials are used. The R-ladder of circularity is essential to integrate in the defence sector to reduce waste and promote circular loops of material use.[116] This will make the defence sector self-sufficient and increase its freedom of action by reducing dependence on other actors.

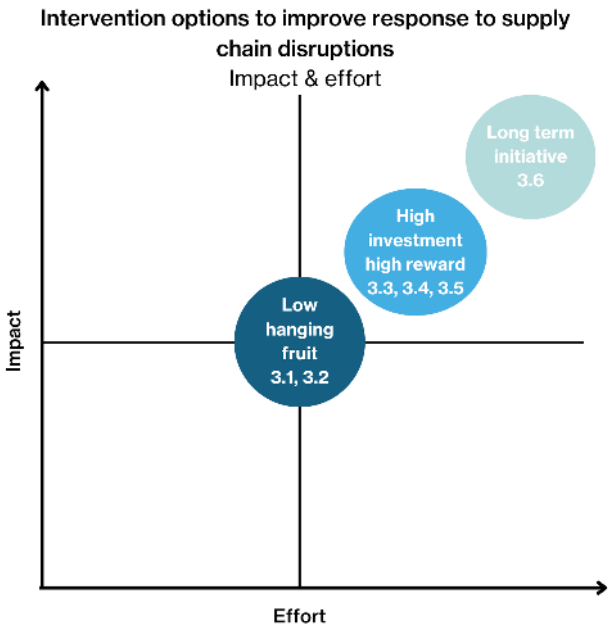
116 'R-Ladder - Strategieën van Circulariteit', Rijksdienst voor Ondernemend Nederland, 2023, https://www.rvo.nl/onderwerpen/r-ladder.

The intervention options are described in Table 15 and the qualitative assessment of expected impact and required effort is indicated in Figure 17. The SWOT analysis is included in Annex 2.

Table 15. Policy intervention options to improve response to supply chain disruptions

Intervention	Description	Anticipated effect	Responsible entity	Classification
3.1. Create a roadmap for a circular and resilient LCF	Create a roadmap with the industry, knowledge institutions and relevant governments to ensure a circular and resilient LCF.	Increased preparedness and ability to take mitigating action, reduced demand for primary materials	EZ, MoD	Low hanging fruit
3.2. Develop a defence crisis/contingency management plan in case of supply chain disruptions	Develop a plan that informs response to disruptions, e.g., to prioritise defence industry in times of crisis.	Increased preparedness and ability to take mitigating action	EZ, MoD, EU	Low hanging fruit
3.3. Enforce stress tests within defence industry including worst-case scenarios	Conduct regular stress tests with the defence industry to simulate supply chain disruptions, with most likely and worst-case scenarios (e.g., using serious games).	Increased preparedness and ability to take mitigating action	EZ, MoD, EU	High investment high reward, Enabler
3.4. Manage existing inventory and optimise the stockpile of strategic critical components/systems	Establish reserves for critical components/systems at risk of geopolitical disruption in MoD warehouse, in cooperation with European allies.	Reduced vulnerability to short-term supply disruptions	MoD, EU, NATO	High investment high reward
3.5. Set up a stockpile for minerals and metals relevant for defence and other vital sectors	Establish a national / European stockpile of critical raw materials to ensure supply for the defence sector during shortages.	Reduced vulnerability to market fluctuations and short-term supply disruptions	EZ, EU	High investment high reward
3.6. Develop programs for circularity for military systems as part of the Dutch National Raw Materials Strategy	Implement circular initiatives for strategic components and materials from retired military systems, as a part of the circular agenda of the Dutch Raw Materials Strategy.	Reduced demand for raw materials, reduced supply chain vulnerabilities	EZ, MoD	Long term initiative

Figure 17. Qualitative assessment of expected impact and required effort of interventions to improve response to supply chain disruptions



5.4. Use procurement levers for supply chain resilience

Procurement is an effective tool to increase supply chain resilience. Through adjustments in procurement strategies, the Ministry of Defence can incorporate resilience as a key component of its purchasing policies. In this study, four types of levers were used to identify policy recommendations that have an impact on supply chain resilience:[117]

1. **Commercial / tactical levers** like spot market sourcing relate to the tactical inventory and supply commitment management best suited for the short-term.
2. **Supply base levers** relate to a change in the firm's supplier network to build up redundancies (e.g., dual sourcing).
3. **Product levers** such as product standardisation can help reduce the number of variants and thus improve flexibility and reduce supplier dependency.
4. **Predictive forecasting levers** such as forecast excellence build the basis for all other levers by increasing transparency and collaboration.

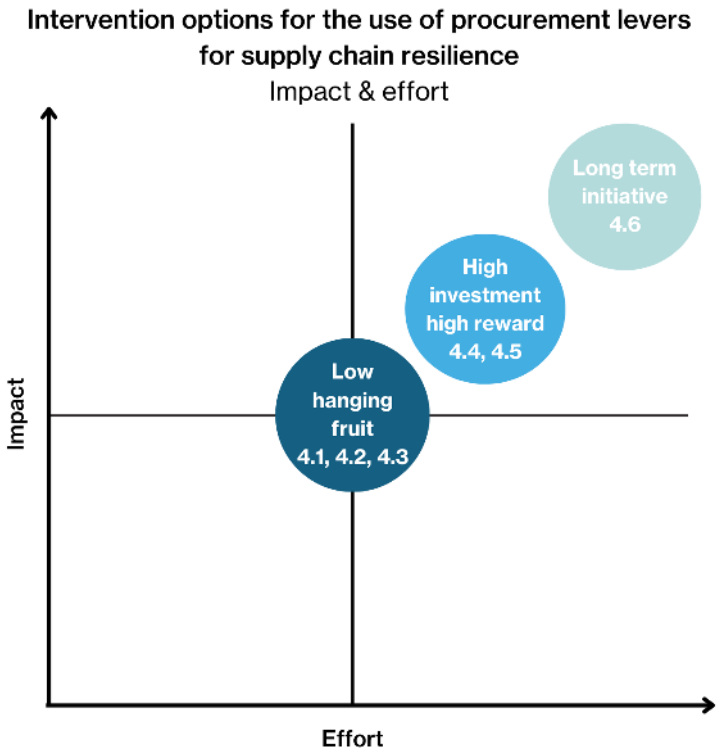
Based on these four types of levers, six policy interventions are formulated, see Table 16. The qualitative assessment of expected impact and required effort is indicated in Figure 18 and the SWOT analysis is included in Annex 2.

Table 16. Policy intervention options for the use of procurement levers for supply chain resilience

Intervention	Description	Anticipated effect	Responsible entity	Classification
4.1. Impose requirements for supply chain risk assessments for critical system manufacturers	Impose requirements on critical system manufacturers to conduct periodic assessments of risks in the supply chain.	Increased supply chain resilience by reducing the dependency on sole sources; Strengthened early warning capacity in case disruptions	MoD	Low hanging fruit, Enabler
4.2. Impose requirements for origin for critical system manufacturers	Impose requirements on critical system manufacturers regarding the country of origin of critical components of their systems (e.g., by limiting the origin of the supplier base to EU/NATO).	Increased supply chain resilience: a supply chain that is more centred around reliable states ("friend-shoring")	MoD, EU, NATO	Low hanging fruit
4.3. Impose requirements for circularity (R-ladder of strategies)	Impose requirements for circularity to be accounted for in the design process of new defence systems.	Reduced need for primary raw materials	MoD	Low hanging fruit
4.4. Impose requirements to incorporate product passports for new systems	Impose requirements when procuring new systems to develop and maintain a product passport.	Informed decision making through the provision of supply chain data; Well monitored stockpiling levels and needs	MoD	High investment high reward, Enabler
4.5. Impose diversification requirements for industry (components and systems)	Impose requirements on/ Incentivise the defence industry to diversify their supply base.	Increased supply chain resilience by reducing the dependency on sole sources; Strengthened early warning capacity in case disruptions	MoD	High investment high reward
4.6. Impose requirements for design and standardisation	Encourage modular design, complexity reduction and product standardisation in defence systems.	Simplified repair procedures, broadened supplier base	MoD, EU, NATO	Long term initiative

117 Resilient supply chain for procurement, PwC/Strategy& (2023), https://www.strategyand.pwc.com/de/en/functions/operations/resilient-supply-chain-for-procurement.html

Figure 18. Qualitative assessment of expected impact and required effort of interventions for the use of procurement levers for supply chain resilience



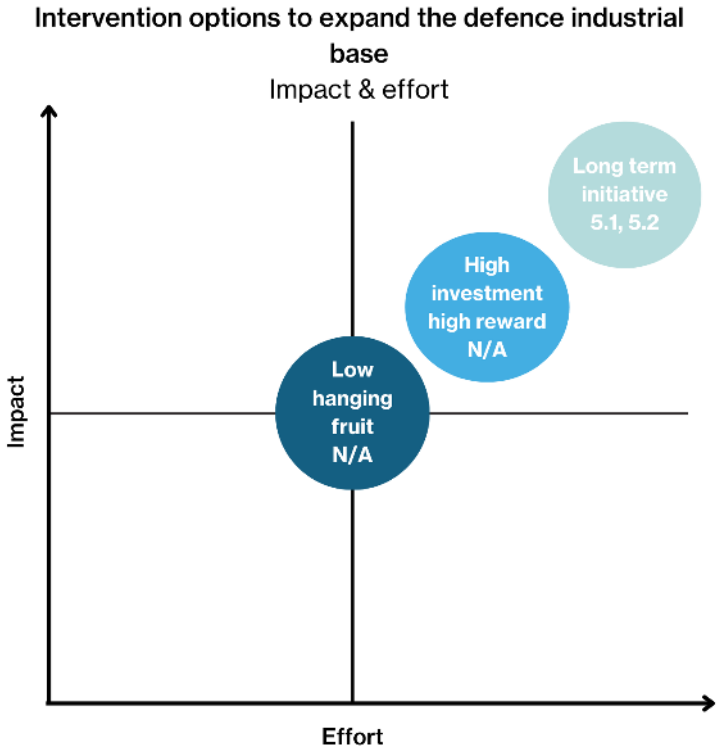
5.5. **Expand the defence industrial base**

The expansion of the defence industrial base, both domestically by developing minimum manufacturing capacity for strategic products and internationally by cooperating more closely with strategic partners and allies, can mitigate the impact of a supply disruption. Developing minimum capacity for the supply of strategic components would ensure continuity in case of a supply crisis. Expanding international production partnerships would ensure alternative options in case the Dutch defence industry faces a supply chain issue, de facto diversifying the domestic manufacturing base. The policy intervention options are presented in Table 17, the qualitative assessment of expected impact and required effort is indicated in Figure 19 and the SWOT is included in Annex 2.

Table 17. Policy intervention options to expand the defence industrial base

Intervention	Description	Anticipated effect	Responsible entity	Classification
5.1. Develop minimum manufacturing capacity for strategic components and systems	Expand the ability to manufacture and supply strategic components and systems within trusted nations (for example EU/NATO).	Enhanced strategic autonomy; Broadened supply base; Increased support for industrial base	EZ, EU, NATO	Long term initiative
5.2. Expand international defence production partnerships	Work with partners and allies to strengthen supply security and derisk supply chains.	Broadened and diversified supply base	EZ, EU, NATO	Long term initiative

Figure 19. Qualitative assessment of expected impact and required effort of interventions to expand the defence industrial base



6. Concluding remarks

The LCF, like every defence platform, relies on imports of (critical) raw materials and strategic components from third countries. Supply chains are global, very complex and involve thousands of actors, meaning that a complete mapping of the LCF supply chain to the level of detail of raw materials is a highly challenging task. Yet defence is a sector of national security importance. While not all dependencies pose threats to the platform's operational availability and relevance, it is crucial that Ministries of Defence and the defence industry in the Netherlands, the EU and NATO, are able to ensure resilient supply chains that allow the uninterrupted functioning of existing and new systems even amidst global supply crises.

The main dilemma that emerged from this research refers to the need to develop effective and sustainable policy interventions in an inherently uncertain and data-scarce context. Five high-level recommendations have been developed to support policymakers in the Netherlands and allied countries in addressing this dilemma. To support their operationalisation, 24 policy interventions options have been identified, but it is up to the Dutch government to determine which are the most fit for purpose and the details of their potential implementation.

Annex 1. Geopolitical vulnerabilities in raw materials supply chains

This annex includes the results of the likelihood of supply disruption assessment for each of the 29 raw materials analysed.

Bauxite (Aluminium) – Medium likelihood of supply disruption

Bauxite extraction primarily takes place in Australia (28%), followed by China (21%) and Guinea (18%). The processing of aluminium is more concentrated, with 56% of total global supplies being processed in China, followed by Russia and India with 6% each.[118] The reliance on these countries is further reinforced by the three main companies operating in aluminium processing being Chinese- (Chinalco and Hongqiao) and Russian-owned (Rusal).[119] Although the high end of life recycling input rate of aluminium in Europe somewhat mitigates the likelihood of disruption, aluminium's low level of substitution possibilities has the opposite effect.[120]

Dutch bilateral relations with the countries where extraction takes place are stronger than relations with aluminium processing supplier countries. The probability of disruption in the extraction phase is high due to the large global political influence of China, and the instability of Guinea.[121] The procession phase of aluminium is more vulnerable to disruptions, considering the possibility of China and Russia acting as allies in opposing Western states. However, aluminium supply chains have not yet been directly affected by rising Chinese assertiveness, and only a limited set of aluminium products has been included in the EU sanctions on Russia.[122]

118 European Commission, *EU Study on the Critical Raw Materials for the EU 2023: Final Report* (LU: Publications Office of the European Union, 2023), https://data.europa.eu/doi/10.2873/725585.

119 Statista, 'World's Leading Primary Aluminium Producing Companies', Statista, 2023, https://www.statista.com/ statistics/280920/largest-aluminum-companies-worldwide/.

120 European Commission, *Study on the Critical Raw Materials of the EU 2023*, 2023

121 FSI, 'Fragile State Index Country Dashboard', 2024, https://fragilestatesindex.org/global-data/; 'Global Power Index', Pardee Center for International Futures, 2022, https://www.ifs.du.edu/IFs/frm_GraphicalDisplay/%22Power%20Measure%2c%20Global%20Power%20Index%2c%20History%20and%20Forecast%22/True/0/0-185/1/2100.

122 'Industry Group Urges EU to Impose Broader Sanctions on Russian Aluminium', *Reuters*, 17 November 2023, sec. Commodities, https://www.reuters.com/markets/commodities/industry-group-urges-eu-impose-wider-sanctions-russian-aluminium-2023-11-17/; Emily Benson and Thibault Denamiel, 'China's New Graphite Restrictions', 23 October 2023, https://www.csis.org/analysis/chinas-new-graphite-restrictions.

Baryte (Barium) - Medium likelihood of supply disruption

Baryte is predominantly extracted in China, which accounts for 31,5% of total global supplies, and India, which accounts for 25,1%. Morocco is the world's third supplier of barytes-barium (8,9%).[123] Compared to other critical materials, the supply of barium is relatively diversified. However, barium sulphate is currently difficult to recapture through end-of-life recycling, with the material having a recycling input rate of 0% in Europe. Moreover, substitution options are limited. This increases the probability of supply chain disruption.[124]

The high dependency on China is a critical point considering the rising instances of Chinese exploitation of economic interdependencies, despite European efforts to implement de-risking and strategic autonomy initiatives.[125] Moreover, heightened risk of Sino-American competition, a possible clash of the two superpowers over Taiwan, and closer Sino-Russian ties are putting pressure on the EU's initial neutral approach towards economic exchanges with China.[126]

When it comes to other suppliers, the Netherlands is strengthening and expanding trade and investment relations with India in light of the 'Make in India' initiative.[127] However, India's ambiguous positioning towards China, Russia, and the West adds uncertainty and unpredictability to the future of Indo-Dutch relations. In fact, Western relations with India have been complicated by New Delhi's neutral stance on the Russian invasion of Ukraine and by the weakening of democratic values in India under Modi's regime.[128]

Boron (Borate) - Medium likelihood of supply disruption

Boron, a material found in sodium borates, is largely extracted and processed in Türkiye, which accounts for 48,4% of extraction and 44,8% of processing of global boron supplies, followed by the US (24,9% extraction, 23,4% processing) and Chile (10,7% extraction, 10% processing). The recycling input rate of boron is close to zero in Europe.

Dutch-Turkish economic relations are historically consistent, with significant trade, investment flows, and technological collaboration between the two countries.[129] The Netherlands and Türkiye are militarily cooperating in NATO to face common security challenges. Nonetheless, tensions stemming from Türkiye's broader geopolitical manoeuvres and internal political challenges have somewhat strained Ankara's relations with NATO and EU members in the past. Given the current political climate, future clashes cannot be excluded.[130]

123 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

124 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

125 'Evaluating Europe's Economic Security Strategy', CSIS, July 13 2023, https://www.csis.org/analysis/evaluating-europes-economic-security-strategy.

126 'Navigating Tides: The European Union's Expanding Role in the Indo-Pacific', CSIS, March 5 2024, https://www.csis.org/analysis/navigating-tides-european-unions-expanding-role-indo-pacific.

127 Indian Embassy in The Hague, 'Brief on India-Netherlands Bilateral Trade and Investment', accessed 21 August 2024, https://indianembassynetherlands.gov.in/page/overview-of-indian-economy/.

128 BTI, 'India Country Report 2024', 2024, https://bti-project.org/en/reports/country-report/IND.

129 Diplomat Magazine, 'Türkiye and the Netherlands: Long History, Strong Future', October 1 2023, https://diplomatmagazine.eu/2023/10/01/turkiye-and-the-netherlands-long-history-strong-future/.

130 Burhanettin Duran, 'Where is Turkish foreign policy headed in 2024?', SETA-V, January 1 2024, https://www.setav.org/en/opinion/where-is-turkish-foreign-policy-headed-in-2024; Ministry of Foreign Affairs of Republic of Türkiye, 'Relations between Türkiye and the Netherlands', mfa.gov.tr, https://www.mfa.gov.tr/relations-between-turkiye-and-the-netherlands.en.mfa.

Chromium - Low likelihood of supply disruption

The global supply of chromium is primarily sourced in South Africa, Kazakhstan, and India, with all three countries leading in both the extraction and processing phase. Extraction of chromium is for the most part concentrated in South Africa (56%). The processing phase is more diversified, with 24% of total global supplies of chromium being processed in South Africa, followed by Kazakhstan (14%) and India (9%). Although the current recycling input rate of chromium in Europe is relatively high, substitution options are limited.[131]

South Africa, India, and Kazakhstan have relatively stable economic ties with the Netherlands, but simultaneously perform a balancing act in relations with the West, China and Russia.[132] Thus, in the case of increased geopolitical tensions, global chromium supplies would face a higher disruption probability.

Cobalt - Low likelihood of supply disruption

The extraction of cobalt is concentrated in the DRC, with 62,8% of global supplies stemming from the DRC. Russia (6,6%) and Canada (4,1%) are the other two major suppliers of cobalt ores. Processing of cobalt mainly takes place in China, which accounts for 59,6% of global supplies, followed by Finland (11,4%) and Belgium (5,3%). Like many other critical materials, there is almost no economically viable alternative to cobalt. However, the relatively high recycling input rate of 22% in Europe mitigates the probability of disruptions.[133]

Due to ongoing conflicts in the DRC between more than one hundred non-state armed groups in the eastern region, the DRC ranks high on the 2024 Fragile State Index.[134] This poses a problem for the (responsible) sourcing of cobalt from the country, especially considering the large share of cobalt ores originating from the DRC. Overall, however, Dutch-Congolese relations are consolidated and mainly focused on improving stability, security, and regional cooperation through initiatives like the Multi-Annual Country Strategy and the United Nations Organisation Stabilisation Mission in the DRC.[135] Besides the DRC, the Netherlands also maintains strong relations with Finland and Belgium with regards to cobalt extraction, with both countries being close allies in NATO and fellow members of the EU.

Copper - Low likelihood of supply disruption

Although not considered a CRM, copper is included in the EU's list as a strategic raw material due to its wide range of applications. Chile leads in extraction phase, with 28% of the global supply of copper being extracted here, followed by Peru (12%) and China (8%). China has the largest share of all suppliers in the processing phase, with 38% of global supplies, followed

131 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

132 'BTI India Country Report 2024', BTI 2024, accessed 20 August 2024, https://bti-project.org/en/reports/country-report/IND; 'Putin hosts 'dear friend' Modi on first trip to Russia since Ukraine war', *Al Jazeera*, accessed 20 August 2024, https://www.aljazeera.com/news/2024/7/8/indias-modi-makes-first-russia-visit-since-ukraine-invasion; 'South Africa in the Emerging World Order', *Carnegie Endowment for International Peace*, December 21 2023, https://carnegieendowment.org/research/2023/12/south-africa-in-the-emerging-world-order?lang=en.

133 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

134 FSI, 'Congo Democratic Republic', Country Dashboard, 2024, https://fragilestatesindex.org/country-data/.

135 Ministry of Foreign Affairs of the Kingdom of the Netherlands, 'Multi-Annual Country Strategy 2023-2026 Great Lakes Region', https://www.netherlandsandyou.nl/documents/d/uganda/multi-annual-strategy-great-lakes-region-2023-2026-public-version-pdf?download=true; UN, 'MONUSCO | United Nations Organization Stabilization Mission in the DR Congo', https://monusco.unmissions.org/en.

by Chile (10%) and Japan (6%). Notably, copper has a high recyclability rate and maintains its performance through repeated recycling. This allows for a degree of self-sufficiency from supplier countries. Besides, copper's substitution score is lower compared to other materials, which further mitigates its disruption probability.[136]

Chile and Peru play a central role in the global supply chain of copper. The 2023 EU Latin America strategy mentions the EU's aspiration to strengthen ties with Latin-American countries, in particular through the Global Gateway initiative. The EU-Latin America and the Caribbean Global Gateway Investment Agenda, a political commitment which identifies investment opportunities, includes investments in infrastructure, renewable energy, and critical raw materials, amongst others.[137]

Gallium and Germanium - High likelihood of supply disruption

Gallium and germanium share similar physical characteristics and are largely controlled, in both the extraction and processing phase, by the same key players. Gallium is a by-product of processing bauxite ore for aluminium and zinc ore, while germanium is primarily derived from zinc refineries and coal fly ash.[138] Within the processing stage of the gallium and germanium supply chain, China holds a 94% and 83% share respectively, with Russia being the second-largest supplier of both materials (2% for gallium and 5% for germanium). Ukraine is the third-largest supplier of gallium (2%), and Belgium ranks third for germanium supply (4.5%). Other factors, like the difficulty of recycling and non-sufficient substitution materials, contribute to the high disruption probability of both gallium and germanium.[139] Gallium is particularly difficult to recycle.[140] While germanium also has a low recycling rate, new technologies for recycling germanium from other sources are emerging, and further development in this area might mitigate its disruptions' risk.[141]

Dutch relations with China are multifaceted. While the two countries engage in consistent trade exchanges, their economic relations came recently across a series of bumps in the road, including the ASML question and the 2023, China-imposed export restrictions on gallium and germanium.[142] Dutch relations with Russia have significantly worsened since the outbreak of the war in Ukraine, after which NATO identified Russia as the "most significant and direct threat" to the Allies.[143] As a result of the war, Ukraine faces high political instability. Lastly, while Belgium is a close partner of the Netherlands, only 4.5% of germanium is supplied by this country.

136 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

137 European Commission, 'New Agenda to strengthen EU's partnership with Latin America and the Caribbean', 7 June 2023, https://ec.europa.eu/commission/presscorner/detail/en/ip_23_3045.

138 'Germanium', Minerals Education Coalition, accessed 6 December 2023, https://mineralseducationcoalition.org/elements/germanium/; 'Gallium Price, Occurrence, Extraction, Use | Institute for Rare Earths and Metals', Institut für Seltene Erden und strategische Metalle e.V., accessed 6 December 2023, https://en.institut-seltene-erden.de/seltenne-erden-und-metalle/strategische-metalle-2/gallium/.

139 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

140 Maximilian Ueberschaar, Sarah Julie Otto, and Vera Susanne Rotter, 'Challenges for Critical Raw Material Recovery from WEEE – The Case Study of Gallium', Waste Management, Special Thematic Issue: Urban Mining and Circular Economy, 60 (1 February 2017): 534–45, https://doi.org/10.1016/j.wasman.2016.12.035.

141 Hossein Kamran Haghighi and Mehdi Irannajad, 'Roadmap for Recycling of Germanium from Various Resources: Reviews on Recent Developments and Feasibility Views', Environmental Science and Pollution Research 29, no. 32 (1 July 2022): 48126–51, https://doi.org/10.1007/s11356-022-20649-5.

142 'No Signs Yet of Gallium or Germanium Shortage - IEEE Spectrum', accessed 30 November 2023, https://spectrum.ieee.org/gallium-and-germanium.

143 'Relations with Russia', NATO, accessed 20 August 2024, https://www.nato.int/cps/en/natohq/topics_50090.htm.

Gold – Very low likelihood of supply disruption

Extraction of gold is relatively diversified compared to other materials, with the top three suppliers China (12,3%), Australia (9,4%), and Russia (8,6%) combined merely accounting for roughly 30% of global gold supplies. The highly diversified supply base of gold makes it overall a very low-risk material. In fact, the EU has many more opportunities for diversification when it comes to gold suppliers, meaning that geopolitical disruptions in the top 3 supplier countries could be easily mitigated.[144]

Iron - Low likelihood of supply disruption

Australia leads the extraction of iron with 37% of global supplies, followed by Brazil (18%) and China (15%). Notably, China controls over 52% of the processing market, giving it significant influence over global aluminium supplies. The rest of iron processing is distributed among various suppliers with India and Japan being the second and third suppliers respectively, and providing 6% of global supplies each.[145] Iron recycling is crucial for both current and future iron supply. Iron can be recycled indefinitely without quality loss, and recycling saves energy compared to the extraction and processing of new iron resources.[146] Recycling thus plays a crucial role in mitigating global market fluctuations. Despite this, the EU's iron recycling input rate over 2023 was merely 31%.[147]

Australia's central position enhances supply security for the Netherlands, especially as Australia and the EU strengthen their relationship amidst rising tensions in the Indo-Pacific.[148] While Brazil remains a volatile partner, internal political developments and the Netherlands' relative political influence contribute to the stability of the iron supply chain.[149]

Lead - Low likelihood of supply disruption

Lead is not considered to be a CRM, but is nevertheless essential in diverse manufacturing processes. China is the top supplier, accounting for 43.4% of extracted and 43.2% of processed lead worldwide. Australia (9,8%) and the US (6,4%) are two other leading suppliers in the extraction phase, and the US (9,5%) and South Korea (6,7%) follow China in the processing stage. The high recyclability of lead, with an end of life recycling input rate of 83%, adds to the low disruption probability.[150]

For alternatives to Chinese lead supplies, the Netherlands relies on the US, Australia, and South Korea. All three countries have strong economic, diplomatic, and military ties with the Netherlands. Despite protectionist policies like the Inflation Reduction Act, EU-US economies

144 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

145 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

146 Market Research Future, 'Iron Ore Market Information by Product Type, Form, and Region - Forecast till 2030', January 2023, https://www.marketresearchfuture.com/reports/iron-ore-market-8004.

147 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

148 Market Research Future, 'Iron Ore Market Information by Product Type, Form, and Region - Forecast till 2030', January 2023, https://www.marketresearchfuture.com/reports/iron-ore-market-8004.

149 Sofia Moutinho, 'After Lula's Win, "a Huge Relief!"', Science 378, no. 6619 (2022): 464–464, https://doi.org/10.1126/science.adf6054; 'Formal Bilateral Influence Capacity | International Studies', Pardee Center for International Futures, accessed 7 December 2023, https://korbel.du.edu/pardee/content/formal-bilateral-influence-capacity.

150 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

remain highly integrated. The EU is the US's largest trading partner, the US is the EU's second largest trading partner, and both are the strongest sources for FDI in each other's economy. [151] A return of Trump(-like) policies will likely put EU-US relations under increased pressure, but the extent to which such a stance will result in structural and long-term changes in the relationship is uncertain. The Dutch Indo-Pacific Guidelines considers both Australia and South Korea to be close allies to NATO in the region and plans to collaborate closely with the countries in the years to come.[152]

Lithium - Medium likelihood of supply disruption

Lithium extraction mainly takes place in Australia, which accounts for 53% of global supplies, followed by Chile (24,1%) and China (10,2%). The processing of lithium is concentrated in China (56,2%), Chile (31,1%), and Argentina (10,5%). With roughly 87% of extraction and 97% of processing of global lithium supplies being concentrated in these top supplier countries, and with a low end of life recycling input rate and no viable alternatives to lithium, its supply chain has a high probability of disruption.

The risk of disruption is somewhat mitigated by the relatively stable Dutch relations with Australia, Argentina, and Chile. Argentina and the Netherlands share a long-standing partnership, which will mark 200 years in 2025. This partnership is characterised by significant trade and investment, with the Netherlands being one of Argentina's main commercial partners and the third-largest foreign direct investor in the country.[153] Argentina's current economic and political landscape under President Javier Milei poses both challenges and opportunities. Milei's administration is marked by aggressive economic reforms and attempts to stabilise the Argentine economy, which may create new avenues for Dutch investments, especially in the energy and agriculture sectors.[154] The current economic relationship between the EU and Chile is defined by the Association Agreement signed in 2002. Currently, a modernisation of the trade agreement is being negotiated, which is expected to be finalised in the near future. This agreement will increase the economic cooperation by further liberalising trade and cutting tariffs. Supplying 90 of Dutch lithium imports, the reduction of tariffs under the free trade agreement could lead to an increase in lithium and copper export from Chile to the Netherlands.[155]

151 'United States', European Commission, EU trade relationships by country/region, accessed 20 August 2024, https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/united-states_en.

152 'Indo-Pacific: Guidelines for strengthening Dutch and EU cooperation with partners in Asia', Government of the Netherlands, accessed 20 August 2024, https://www.government.nl/documents/publications/2020/11/13/indo-pacific-guidelines.

153 'Argentina and the Netherlands: a partnership based on common values', Diplomat Magazine, October 4 2020, https://diplomatmagazine.eu/2020/10/04/argentina-and-the-netherlands-sharing-important-common-values/.

154 'Freedom (and poverty) in Argentina: Milei's 100 frenetic days in power and an unprecedented economic experiment', El País English, 19 March 2024, https://english.elpais.com/international/2024-03-19/freedom-and-poverty-in-argentina-mileis-100-frenetic-days-in-power-and-an-unprecedented-economic-experiment.html#.

155 Joost Witteman, Adam Kuzynski, Nils Verheuvel, Nienke Oomes, Thierry Belt, Elisabeth Hoole, Maartje de Groot, Emily van den Burg en Bo Sanger, *Expected Economic Effects of the EU FTAs with Chile, Mexico, and New Zealand* (Amsterdam: SEO, 2023), https://www.government.nl/documents/reports/2023/07/26/expected-economic-effects-of-the-eu-free-trade-agreements-with-chile-mexico-and-new-zealand.

Manganese - Medium likelihood of supply disruption

Manganese extraction is fairly well dispersed among different sourcing countries, of which South Africa (29,3%), Australia (16,3%), and Gabon (14,4%) are the top three suppliers. In the processing stage, China holds the highest share of global supplies with 58,2%, followed by India (13,1%) and Ukraine (4,4%). The end-of-life recycling rate of manganese, combined with the non-existence of viable substitution materials, increases the probability of supply chain disruptions.[156]

The Netherlands is seeking to further strengthen economic ties with South Africa, in addition to EU efforts such as the Southern African Economic Partnership Agreement of 2016.[157] South Africa and the Netherlands are currently in the process of negotiating a bilateral development cooperation framework agreement, including official development assistance up to 100 million euros and focusing on agriculture, healthcare, energy, green water infrastructure and sustainable manufacturing.[158] South Africa also holds a central position in the Dutch Africa Strategy for 2023-2032 which focused on raw materials, business access, renewable energy and digitisation.[159] However, South Africa also closely cooperating with non-Western states and is a member of BRICS and the Non-Aligned Movement.[160] South Africa is unlikely to give up its neutral stance and collaboration with China and Russia, which somewhat puts EU/Dutch-South African states under strain.

Formal military and political cooperation between the Netherlands and Gabon is limited and mostly occurs through international forums and UN peacekeeping missions. These efforts mainly focus on maintaining stability in Central Africa, following the military coup in Gabon in 2023.[161] The two countries share a robust trade relationship, particularly in dairy, poultry, and agricultural products, with Dutch imports from Gabon reaching $204 million in 2022.[162] Key collaboration areas include the oil and gas sector, where Dutch expertise can enhance efficiency and environmental standards, and agriculture, where the Netherlands can support sustainable farming practices to boost productivity and food security.[163]

156 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

157 'South Africa', European Commission, EU trade relationships by country/region, accessed August 21 2024, https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/south-africa_en.

158 Government of the Netherlands, 'Joint Communiqué of the Third Meeting of the South Africa – The Netherlands Joint Commission for Cooperation', October 18 2023, https://www.government.nl/documents/diplomatic-statements/2023/10/18/joint-commission-for-cooperation-south-africa-the-netherlands.

159 Government of the Netherlands, *Do what we do best: A strategy for Foreign Trade and Development Cooperation* (The Hague: Ministry of Foreign Affairs, 2022), https://www.government.nl/documents/policy-notes/2022/10/10/policy-document-for-foreign-trade-and-development-cooperation-do-what-we-do-best.

160 'International relations', South African Government, About SA, accessed 21 August 2024, https://www.gov.za/about-sa/international-relations.

161 'Gabon: Participants in national dialogue complete work', Africa News, April 29 2024, https://www.africanews.com/2024/04/29/gabon-participants-in-national-dialogue-complete-work/; IDEA, 'Gabon', Global State of Democracy Initiative, accessed August 21 2024, https://www.idea.int/democracytracker/country/gabon.

162 OEC, 'Gabon/Netherlands', OEC World, accessed August 21 2024, https://oec.world/en/profile/bilateral-country/gab/partner/nld.

163 African Development Bank Group, 'Gabon Economic Outlook,' Countries, Central Africa, Gabonese Republic, accessed August 21 2024, https://www.afdb.org/en/countries/central-africa/gabon/gabon-economic-outlook; 'Gabon: 2024 Economic Overview', The Business Year, November 28 2023, https://thebusinessyear.com/article/gabon-2024-economic-overview/.

Molybdenum - Low likelihood of supply disruption

The extraction of molybdenum is moderately diversified, with the main suppliers being China, which accounts for 38,3% of global supplies, followed by Chile with 21,3% and the US with 15,4%. There are no values on the processing of molybdenum. The recycling input rate of molybdenum is 30%, which is relatively high compared to other materials and mitigates the probability of disruption. However, there is no viable substitute for molybdenum.[164]

As mentioned, Sino-Dutch relations are influenced by fears of economic coercion. In the case of molybdenum supplies, economic dependencies on China are mitigated due to the alternative of suppliers with warm ties to the Netherlands.

Neodymium - High likelihood of supply disruption

Global supplies of neodymium are highly concentrated in China. China holds 68,3% in the extraction phase of the supply chain, followed by Australia with 9,9% and the US with 9,2%. Besides, China possesses 84,9% of global supplies of processed neodymium, with Malaysia (10,5%) and Russia (1,9%) being the second and third largest suppliers. The end-of-life recycling input rate of neodymium is extremely low, and with no viable substitution material, overall probability of supply chain disruptions are high.

The Netherlands has good relations with Australia and the US, and is simultaneously deepening its ties with Malaysia. However, these relations are overshadowed by the dominant position of China within the neodymium supply chain.

Nickel - Low likelihood of supply disruption

The overall supply concentration for extraction and processing is relatively low, with the top three supplier countries holding 50% and 54% of the market share respectively. Indonesia is the leading supplier in the extraction process with 26% of global supplies, followed by the Philippines (14%) and Russia (10%). China dominates nickel processing with 33% of global supplies, followed by Indonesia (12%) and Japan (9%). Nickel has a 16% end-of-life recycling rate but it is difficult to replace by a substitute material.[165]

Despite the Netherlands having a long-shared history and close economic relations with Indonesia, Indonesian policies to protect its economic interests impact nickel exports.[166] In 2020, Indonesia implemented an export ban on nickel ore to bolster its national processing industry.[167] Due to growth-boosting foreign investments and increasing demand for electric vehicles, new mining and processing developments in Indonesia have driven significant growth in the global nickel industry in recent years. Between 2021 and 2022, the global nickel

164 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

165 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

166 Rijksoverheid, 'Indo-Pacific: Een Leidraad Voor Versterking van de Nederlandse En EU-Samenwerking Met Partners in Azië', November 13 2020, https://www.rijksoverheid.nl/documenten/publicaties/2020/11/13/indo-pacific-een-leidraad-voor-versterking-van-de-nederlandse-en-eu-samenwerking-met-partners-in-azie.

167 Ankit Ajmera, 'Indonesia's Bauxite Export Ban to Have Limited Impact on China Supply', S&P Global, 25 November 2021, https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/metals/112521-indonesias-bauxite-export-ban-to-have-limited-impact-on-china-supply.

extraction sector grew by 18%, and the processing sector by 17%.[168] As a result of substantial Chinese investments in the Indonesian nickel industry, China has increased its influence in the nickel sector.[169]

Niobium - Medium likelihood of supply disruption

Global niobium supplies are highly concentrated in Brazil. In the extraction phase, Brazil holds 91,8% of global supplies, followed by Canada (6,6%) and Russia (0,6%). In the processing phase, Brazil holds an 88,8% share, with Canada possessing the remaining 11,2%. Within the EU, no niobium is retrieved from recycling in Europe as the recycling input rate of the material is 0%. Moreover, niobium is an extremely difficult material to replace.[170]

Geopolitically speaking, this risk is somewhat low as Dutch-Brazilian ties are relatively strong. Trade between the EU and Brazil mostly revolves around primary products and agriculture, with Brazil being the EU's biggest trading partner in South America.[171] The Netherlands is a large investor in Brazil. In 2022, Brazil was the Netherlands' fifth country for outgoing FDI, accounting for 14% of total incoming Brazilian FDI which could mainly be attributed to enterprises operating in the petroleum industry.[172] When elected in 2019, Bolsonaro adopted a foreign policy that promoted the protection of Brazilian sovereignty. In doing so, he did not refrain from setting Brazil on a course away from European countries, especially by limiting cooperation on climate change. With the recent beginning of Lula's government, political cooperation between Europe and Brazil is expected to be strengthened. Still, Lula's stance of neutrality in the Russo-Ukraine war led its Western allies to criticise the Brazilian government.[173] Brazil's diverting interests and policies in the geopolitical context may thus result in uncertain relations between European states and Brazil.

Relations between the Netherlands and Canada are historically very strong. Economically, Dutch relations are guided by the Canada-European Union Comprehensive Economic Trade Agreement.[174] Politically, Dutch-Canadian relations are guided by the EU-Canada Strategic Partnership Agreement, which established a very comprehensive cooperation based on shared values.[175] The long-term shared NATO membership of both countries further strengthen the ties.

168 International Energy Agency, 'Critical Minerals Market Review 2023' (Paris: IEA, 2023), 54, https://www.iea.org/reports/critical-minerals-market-review-2023.

169 Fitch Solutions, 'Global Nickel Mining Outlook', Fitch Solutions, 4 January 2023, https://www.fitchsolutions.com/bmi/commodities/global-nickel-mining-outlook-04-01-2023.

170 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

171 European Commission, 'Brazil', EU trade relations by country/region, accessed 21 August 2024, https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/brazil_en.

172 CBS, 'Dutch Trade in Facts and Figures', CBS, 2022 https://longreads.cbs.nl/dutch-trade-in-facts-and-figures-2022/foreign-direct-investment-and-multinationals/; Santander, 'Brazil: Foreign investment', accessed 21 August 2024, https://santandertrade.com/en/portal/establish-overseas/brazil/foreign-investment.

173 'How to Understand Brazil's Ukraine Policy', Foreign Policy, 18 May 2023, https://foreignpolicy.com/2023/05/18/russia-ukraine-war-brazil-lula-nonalignment-global-south/.

174 European Commission, 'EU-Canada Comprehensive Economic and Trade Agreement (CETA)', EU trade relationships by country/region, accessed 21 August 2024, https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/canada/eu-canada-agreement_en.

175 EEAS, 'EU-Canada Strategic Partnership Agreement', European Union External Action, accessed 21 August 2024, https://www.eeas.europa.eu/node/13529_en.

Palladium - Medium likelihood of supply disruption

The two main supplier countries are Russia and South Africa, holding a share of 40% and 36% respectively. Canada is the third major supplier of palladium, with a share of 10%. Palladium has a 12% recycling rate in Europe and is difficult to replace in manufacturing.[176]

Political and economic relations with Russia have suffered vastly from the Russian invasion of Ukraine.[177] Although palladium was not directly covered by the EU sanctions on Russia as of December 2023, the financial sanctions led to substantial palladium price increases.[178] While the Dutch economic and political relations with South Africa are largely positive, South Africa has been actively getting closer to Russia. Russo-South African increased intimacy, both economically and militarily, indicates a balancing of relations that has a potential of creating geopolitical tensions.[179]

Samarium - High likelihood of supply disruption

The extraction of samarium is predominantly located in China, which accounts for 68,3% of global supplies, followed by Australia (9,9%) and the US (9,2%). The processing of samarium is highly concentrated, with 84,9% originating from China, 10,5% from Malaysia, and 1,9% from Russia. Samarium's low recycling rate and lack of adequate substitute materials increase the likelihood of supply chain disruptions.[180]

The aforementioned complex relations between the EU and China as the main supplier of samarium pose a risk for supply chain security. Australia and the US are strong economic, political, and military partners to the Netherlands, as mentioned before. Dutch relations with Malaysia are overall relatively stable, as both countries expressed the ambition to further strengthen their relationship and the Netherlands pushing to re-open negotiations for a free trade agreement.[181] Besides, the Netherlands aims to strengthen its relations with Malaysia as part of its Indo-Pacific Strategy.[182] However, Malaysia pursues a foreign policy that revolves around the notion of sovereign neutrality, which is reflected in their National Defence Policy, military exercises, and arms trades: in all these aspects, Malaysia tries to strike a balance between fostering relations with Europe, the US, China and India.[183]

176 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

177 NATO, 'Relations with Russia', NATO, accessed 16 November 2023, https://www.nato.int/cps/en/natohq/topics_50090.htm; CBS, 'Dutch Trade in Facts and Figures', CBS, 2022, https://longreads.cbs.nl/dutch-trade-in-facts-and-figures-2022/.

178 Peter Hobson, 'Palladium Propelled to Record Highs by Russia Supply Concerns', Reuters, 7 March 2022, sec. Business, https://www.reuters.com/business/palladium-propelled-record-highs-by-russia-supply-concerns-2022-03-07/.

179 'South Africa, Russia deepen military ties,' DW, 23 January 2023, https://www.dw.com/en/south-africa-and-russia-deepen-military-ties/a-64489740.

180 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

181 Government of the Netherlands, 'Joint Press Statement between Dato' Saifuddin Abdullah, Minister of Foreign Affairs of Malaysia and Stef Blok, Minister of Foreign Affairs of the Netherlands', 28 March 2019, https://www.government.nl/documents/diplomatic-statements/2019/03/28/joint-press-statement-between-dutch-and-malaysian-ministers-of-foreign-affairs.

182 Rijksoverheid, 'Indo-Pacific: een leidraad voor versterking van de Nederlandse en EU-samenwerking met partners in Azië', 13 November 2020, https://www.rijksoverheid.nl/documenten/publicaties/2020/11/13/indo-pacific-een-leidraad-voor-versterking-van-de-nederlandse-en-eu-samenwerking-met-partners-in-azie.

183 Trend Economy, 'Malaysia', Annual International Trade Statistics by Country (HS), accessed 21 August 2024, https://trendeconomy.com/data/h2/Malaysia/TOTAL.

Silicon - Medium likelihood of supply disruption

Silicon metal is extracted from silica sand, which is abundant worldwide. Currently, the US leads global silica sand production with 41%, followed by China at 8% and India at 5%. Silica sand is used in a variety of industries, ranging from glassmaking to construction, and also for producing silicon metal.[184] The processing of silica sand into silicon metal is predominantly done in China, which processing accounts for 76% of the global supply, followed by Brazil (7%) and Norway (6%). The unique material properties of silicon make it almost irreplaceable for the production of batteries and solar cells, increasing the probability of future supply chain disruptions. Furthermore, as of 2023, no end-of-life silicon metal has been recycled within the EU.[185] This adds to the likelihood of disruption.

The prospect of better relations with smaller suppliers of silicon is overshadowed by the dominant position of China in the processing of silicon metal. Two years ago, Chinese silicon producers reduced production by up to 90%, causing a 300% surge in global silicon prices.[186] With major dependency on China, this can easily happen again.

Silver - Medium likelihood of supply disruption

Global supply of silver is relatively diversified, with Mexico extracting 24% of global supplies, followed by Peru (14%) and China (13%). Secondary supply of silver is hardly retained in Europe, with a recycling input rate in Europe of 4%. The lack of substitute materials for silver adds to this increased probability for disruption. However, due to the relatively wide distribution of silver sources, the overall disruption probability remains medium.[187]

Dutch relations with Mexico and Peru are relatively neutral and mainly limited to the economic domain. Although Dutch-Sino relations could worsen in light of rising political and economic tensions between Beijing and Brussels, the diversified sourcing of silver mitigates the likelihood of disruption.

Tantalum - Medium likelihood of supply disruption

Most tantalum is extracted from the same deposits as niobium and tin, as it does not occur in nature by itself.[188] The main global suppliers of extracted tantalum are the DRC (35,4%), Rwanda (17,3%), and Brazil (15,9%). There are no values for the processing phase of tantalum. Although its supply base is relatively diversified, the low end of life recycling input rate and lack of substitute materials increase the likelihood of supply chain disruptions.[189]

184 Material Insights, 'Silicon/Silica (Si)/(SiO2)', accessed 21 August 2024, https://www.material-insights.org/material/silicon-silica/.

185 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

186 Elsa A. Olivetti et al., 'Lithium-Ion Battery Supply Chain Considerations: Analysis of Potential Bottlenecks in Critical Metals', Joule 1, no. 2 (11 October 2017): 229–43, https://doi.org/10.1016/j.joule.2017.08.019; 'Silicon's 300% Surge Throws Another Price Shock at the World', MINING.COM (blog), 1 October 2021, https://www.mining.com/web/silicons-300-surge-throws-another-price-shock-at-the-world/.

187 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

188 SCRREEN, 'Tantalum, CRMS 2023 – Factsheets, https://scrreen.eu/wp-content/uploads/2023/12/SCRREEN2_factsheets_TANTALUM-update.pdf.

189 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

Geopolitically, Dutch relations with the DRC, Rwanda and Brazil are relatively neutral. The Netherlands and the DRC mostly interact through international forums and UN peacekeeping missions, with the DRC being a significant focus for peacekeeping efforts due to its ongoing conflicts. The Netherlands provides financial, logistical, and personnel support to these missions.[190] The relation between the Netherlands and Rwanda is similar: they mainly interact through international forums and UN peacekeeping missions, focusing on enhancing capabilities in peacekeeping, humanitarian assistance, and crisis management. EU investments are aiming to boost Rwanda's economic ambitions as formulated in their National Strategy for Transformation and Vision 2050.[191]

Titanium - Low likelihood of supply disruption

The global supply chain of titanium is rather diversified, with China (as main supplier) holding a 25,4% share in the extraction stage, and a 35,3% share in processing stage. South Africa, another major supplier of titanium, holds 13,1% of extraction and 9,3% of processing of global supplies. Australia, with 12,1% in extraction, and the US, with 13,9% in processing, are the other two major suppliers. As with many critical materials, titanium is difficult to retrieve through end-of-life recycling in Europe and there are hardly any viable alternatives, which heightens the likelihood of disruption in an otherwise diversified supply chain.[192] Still, the overall likelihood of supply disruptions is low, as relations between the Netherlands and titanium suppliers are relatively stable, except for possible escalation with the Chinese government.

Tungsten - Medium likelihood of supply disruption

The supply of tungsten is highly concentrated in China, with the country holding 82,6% of extraction and 85,6% of processing of global supplies. Vietnam (6,4%) and Russia (2,7%) are the other major suppliers of raw tungsten, while the US (4,4%) and Russia (2,8%) supply processed tungsten. Compared to other materials, tungsten has a relatively high recycling input rate of 42% in Europe, which somewhat mitigates the likelihood of supply disruptions. The Netherlands has strong ties with the US and ties with Vietnam are expected to deepen in light of the EU-Vietnam Free Trade Agreement.[193] However, these relations are overshadowed by the high dependency on China. As such, the high supply concentration and lack of viable substitute materials give tungsten a medium probability of supply chain disruption.[194]

190 Rijksoverheid, 'The Netherlands and The Democratic Republic of the Congo', Ministry of Foreign Affairs, https://forms.office.com/Pages/ResponsePage.aspx?id=2ALcPt0jhU2VMqVrIlhLU0qQTDVJX_BFqw9E2Mr71XxUQUxZNEg4NzBYT1BGQU0xUjFLOTAyWlhYVy4u; ISS, 'SADC prepares to go back to the future in eastern DRC', 19 May 2023, https://issafrica.org/iss-today/sadc-prepares-to-go-back-to-the-future-in-eastern-drc.

191 European Commission, 'Rwanda and the European Union strengthen partnership', 18 December 2023, https://ec.europa.eu/commission/presscorner/detail/en/ip_23_6724; European Commission, 'Republic of Rwanda', International Partnerships, Countries, accessed 21 August 2024, https://international-partnerships.ec.europa.eu/countries/republic-rwanda_en.

192 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

193 European Commision, 'EU-Vietnam Trade Agreement and Investment Protection Agreement', accessed 21 August 2024, https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/vietnam/eu-vietnam-agreement_en.

194 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

Vanadium - Medium likelihood of supply disruption

The supply of vanadium is concentrated in China, which accounts for 61,6% of global supplies, followed by Russia with 19,8% and South Africa, with 10,6%. China is also the predominant supplier of processed vanadium, holding a share of 61,5%, followed by Russia (9,0%) and South Africa (8,2%). The low end of life recycling input rate of vanadium, in combination with a lack of viable substitute materials, adds to the moderately-high probability of supply chain disruptions.[195] Dutch relations with the two main suppliers of Vanadium, China and Russia, have recently worsened. Moreover, the complex position of South Africa could pose problems in case of increased geopolitical tensions.

Zinc - Low likelihood of supply disruption

The supply of extracted zinc is highly diversified, with 32% of extracted zinc being sourced from China, followed by Peru (12%) and Australia (9%). The processing phase is more concentrated, with China refining 45% of global supplies, followed by South Korea (7%) and India (5%). Besides, zinc has a relatively high recycling input rate in Europe (34%) and low substitution rate, further limiting this disruption probability.[196] Apart from China, Dutch/EU relationships with suppliers of zinc are very good. The Netherlands has strong military and political ties with Australia and South Korea, as both countries are close NATO partners in the Indo-Pacific.

Zirconia - Low likelihood of supply disruption

The top three producing countries of extracted zirconia are Australia (33,6%), South Africa (23,4%), and Mozambique (11,2%). The recycling rate of the material is 12% in Europe, higher than most critical materials. Still, there is no viable substitute for zirconia.[197]

Dutch relations with the supplier countries of zirconia are overall stable. The Netherlands has strong economic ties with Australia, and closer political ties between the Netherlands and Australia are expected in light of strategic partnerships in the Indo-Pacific.[198] Although South Africa is the EU's main trading partner in Africa, the South African alignment with countries like China, Russia or countries in the Non-Aligned Movement might worsen relations. Dutch-Mozambican relations are overshadowed by the fragility of the African country.[199]

195 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

196 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

197 European Commission, *Study on the Critical Raw Materials of the EU*, 2023.

198 Rijksoverheid, 'Indo-Pacific: een leidraad voor versterking van de Nederlandse en EU-samenwerking met partners in Azië', 13 November 2020, https://www.rijksoverheid.nl/documenten/publicaties/2020/11/13/indo-pacific-een-leidraad-voor-versterking-van-de-nederlandse-en-eu-samenwerking-met-partners-in-azie.

199 FSI, 'Fragile State Country Dashboard 2024', 2024, https://fragilestatesindex.org/country-data/.

Annex 2. Policy interventions and SWOT analysis

1. Enhance awareness, understanding and skills

1.1. Enhance awareness and understanding within government of supply chain risks in the defence sector

Description: Depending on their existing level of knowledge, upskill government staff to evolve from unknown unknowns; to known unknowns; to known knowns.

Anticipated effect: Informed policy making and implementation for CRM dependencies in the defence sector

Position in the supply chain: From refining to disposal

Responsible entities: EZ, MoD

Classification: Low hanging fruit, Enabler

Strengths	Opportunities
• Relatively easy to implement	• Enables other interventions
Weaknesses	**Threats**
• Indirect intervention • Limited existing specific information on individual defence supply chains • Financially costly, communication between operations and policy is sometimes insufficient	• Lack of continuity of government staff • Prioritization of other ongoing work

1.2. Create dialogue within defence industry on CRM and supply chain risks

Description: Raise awareness among defence industry players that CRM and supply chain security should be prioritised by organising regular meetings, involving them in working groups etc. These dialogues could also encourage the development of joint solutions.

Anticipated effect: Increased urgency for industry to act

Position in the supply chain: From extraction to manufacturing

Responsible entities: EZ, MoD, EU

Classification: Low hanging fruit, Enabler

Strengths	Opportunities
• Relatively easy to implement as it's already in place with other types of industries	• Synergise efforts of government and defence industry and avoid duplication of work on CRM initiatives
Weaknesses	**Threats**
• Defence industry is / might not be aware of their higher up stream supply chain risks	• Requires resources from defence industry

1.3. Create supply chain insights into Dutch critical systems manufacturers in the defence sector

Description: Impose requirements on Dutch manufacturers to map their supply chains and identify risks.

Anticipated effect: Informed policy making and implementation. Strengthened resilience of NLDTIB to CRM disruptions.

Position in the supply chain: From refining to operation & maintenance

Responsible entities: EZ, MoD, BZK

Classification: High investment high reward, Enabler

Strengths	Opportunities
• Ease of access to information and companies in NL; Well organised defence industrial platform (NIDV)	• Enables other interventions • Fosters public-private cooperation throughout the value chain
Weaknesses	**Threats**
• Indirect intervention • Financially costly and time consuming	• Burden on Dutch industry

1.4. Invest in technical know-how for skilled workers in Dutch defence sector

Description: Support the development of (public or private) technical educational programs and trainings for skilled workers in the field of raw materials as well as manufacturing, maintenance and disposal of defence applications.

Anticipated effect: Increased availability of skilled NL labour force

Position in the supply chain: From extraction to disposal

Responsible entities: EZ, MoD, EU

Classification: Long term initiative, Enabler

Strengths	Opportunities
• High demand for skilled labour in NL and EU	• Enables other interventions • Could encourage public-private partnerships (e.g., if companies play an active role in training people)
Weaknesses	**Threats**
• Indirect intervention • Lack of focus on defence specific skills in current curricula • Requires knowledge on current shortages to be effective • It shows that this is a weakness to the defence sector	• The current labour force shortages, exacerbated by the high demand for skilled personnel in other sectors, might impede the effectiveness of this intervention

1.5. Invest in CRM alternatives for the defence sector (substitution)

Description: Support research and development of applications with enhanced performance and reduced CRM content.

Anticipated effect: Reduced CRM dependencies

Position in the supply chain: Refining, manufacturing

Responsible entities: EZ, MoD, EU, NATO

Classification: Long term initiative

Strengths	Opportunities
• Strong research capabilities and institutions in NL	• Develop synergies with the civil sector
Weaknesses	**Threats**
• CRM are typically very difficult to substitute	• Might reduce performance or durability of defence systems

2. Integrate the defence industry in CRM-related activities

2.1. Involve MoD in policy development around supply chain resilience

Description: Involve MoD and defence industry in relevant national discussions around the implementation of the National Raw Materials Strategy.

Anticipated effect: Defence perspective incorporated in national CRM policies

Position in the supply chain: Extraction, refining

Responsible entities: MoD, EZ

Classification: Low hanging fruit

Strengths	Opportunities
• Relatively easy to implement • Strong connection between EZK and MoD on DIS • Already happening to some extent	• Synergise efforts of government and defence industry and avoid duplication of work on CRM initiatives
Weaknesses	**Threats**
• Lack of knowledge on dependence of specific minerals	• Requires resources EZK and MOD • Ongoing work might be prioritized

2.2. Incorporate the interests of MoD and defence industry in Dutch representation in European fora around CRM Act

Description: Incorporate the interests of MoD and defence industry in the Dutch representation in relevant European fora around the implementation of the CRM Act.

Anticipated effect: Defence perspective incorporated in European CRM policies

Position in the supply chain: Extraction, refining

Responsible entities: EZ, MoD, EU

Classification: Low hanging fruit

Strengths	Opportunities
• Relatively easy to implement as it's already in place with other types of industries	• Synergise efforts of government and defence industry and avoid duplication of work on CRM initiatives
Weaknesses	**Threats**
• Defence industry is / might not be aware of their higher up stream supply chain risks • It shows weaknesses within the MoD • European cooperation on defence issues can be challenging	• Requires resources from defence industry

2.3. Increase defence involvement in existing international CRM agreements and initiatives

Description: Involve and take into account the needs of the defence industry in international CRM agreements and initiatives outside of the EU/NATO.

Anticipated effect: Increased security of supply

Position in the supply chain: Extraction, refining

Responsible entities: EU

Classification: Low hanging fruit

Strengths	Opportunities
• A lot of initiatives currently under development in the civil sector	• Develop synergies with the civil sector
Weaknesses	**Threats**
• Defence industry is not aware of their higher upstream supply chain risks	• It may not directly affect defence due to complexity of supply chain

2.4. Support ongoing domestic/ EU production incentives for minerals and metals relevant for the defence sector, including financial or regulatory support

Description: Leverage initiatives and policies aiming to increase self-sufficiency for CRM for the defence sector.

Anticipated effect: Lowered regulatory, institutional and financial barriers; Increased support for the competitiveness of EU firms

Position in the supply chain: Extraction, refining

Responsible entities: EZ

Classification: Low hanging fruit, enabler

Strengths	Opportunities
• Large scale industrial base and good innovative/ start-up ecosystem in Northwestern Europe can attract investments	• Increase self-sufficiency of CRM
Weaknesses	**Threats**
• Indirect intervention	• It may not directly affect defence due to complexity of supply chain

2.5. Make connections between defence industry, commercial actors and CRM producers in Europe

Description: Leverage existing initiatives and investments of the civil sector by establishing a presence of the defence sector in strategic fora.

Anticipated effect: Increased supply security of materials; Increased support for the competitiveness of EU firms

Position in the supply chain: From extraction to manufacturing

Responsible entities: EZ

Classification: Low hanging fruit, Enabler

Strengths	Opportunities
• Well organised defence industry • Many initiatives already taking place in the civil sector	• Increase self-sufficiency of CRM
Weaknesses	**Threats**
• Difficult to measure effectiveness	• It may not directly affect defence due to complexity of supply chain if the Dutch defence industry is not in contact with CRM suppliers

3. Improve response to supply chain disruption

3.1. Create a roadmap for a circular and resilient LCF

Description: Create a roadmap with the industry, knowledge institutions and relevant governments to ensure a circular and resilient LCF.

Anticipated effect: Increased preparedness and ability to take mitigating action, reduced demand for primary materials

Position in the supply chain: Manufacturing, disposal

Responsible entities: EZ, MoD

Classification: Low hanging fruit

Strengths	Opportunities
• MoD has a high degree of control over maintenance/ disposal of defence systems • The National Programme on Circular Economy is well developed	• Develop synergies with the civil sector • Promotes circular economy
Weaknesses	**Threats**
• Recycling to retrieve CRM is not yet part of disposal of weapons systems • Materials don't go back into the system	• Security requirements might lead to increase in cost for disposal/recycling

3.2. Develop a defence crisis/contingency management plan in case of supply chain disruptions

Description: Develop a plan on how to respond to disruptions, e.g. to prioritize defence industry in times of crisis.

Anticipated effect: Increased preparedness and ability to take mitigating action.

Position in the supply chain: Operation & maintenance

Responsible entities: EZ, MoD, EU

Classification: Low hanging fruit

Strengths	Opportunities
• Scenario planning / Crisis simulation is a core capacity of MoD, policy framework exists	• Increases robustness for initial supply chain shocks • If more ministries that are reliant on CRM are involved, it supports cross-governmental policy coherence and coordination
Weaknesses	**Threats**
• Lack of awareness and understanding on specific CRM supply chains risks and crises • Complexity of the subject: a lot of scenarios are possible for different minerals, components and systems.	• Does not increase resilience if mechanisms to execute the plan are not in place

3.3. Enforce stress tests within defence industry including worst case scenarios

Description: Conduct regular stress tests with the defence industry to simulate supply chain disruptions, with most likely and worst-case scenarios (e.g., using serious games).

Anticipated effect: Increased preparedness and ability to take mitigating action

Position in the supply chain: Assembly, operation & maintenance

Responsible entities: EZ, MoD, EU

Classification: High investment high reward, Enabler

Strengths	Opportunities
• Defence industry is used to stress test and analyse resilience • Well organised defence industrial platform (NIDV) • Well organised defence Ecosystems	• Increases awareness of procedures and knowledge on bottlenecks and weak points
Weaknesses	**Threats**
• Lack of awareness and understanding on specific CRM supply chains risks and crises (a lot of scenarios are possible for different minerals, components and systems)	• Requires resources from defence industry

3.4. Manage existing inventory and optimise the stockpile of strategic critical components/systems

Description: Establish reserves for critical components/systems at risk of geopolitical disruption in MoD warehouse, in cooperation with European allies.

Anticipated effect: Reduced vulnerability to short-term supply disruptions

Position in the supply chain: From manufacturing to operation & maintenance

Responsible entities: MoD, EU, NATO

Classification: High investment high reward

Strengths	Opportunities
• MoD already stockpiles components as part of their way of working	• Increases potential for international collaboration and pooling of stock-piles (risk sharing)
Weaknesses	**Threats**
• Disruptions from CRM dependencies are not yet considered in the current way of working of the MoD • Very costly to incorporate for all crit-ical systems.	• Increased demand that can lead to higher prices and shortages ("race to the bottom") • Increases protectionist behaviours

3.5. Set up a stockpile for minerals and metals relevant for defence and other vital sectors

Description: Establish a national / European reserve of critical raw materials to ensure supply for the defence sector during shortages.

Anticipated effect: Reduced vulnerability to market fluctuations and short-term supply disruptions

Position in the supply chain: Extraction, refining

Responsible entities: EZ, EU

Classification: High investment high reward

Strengths	Opportunities
• NL has good logistics, transport, specialized storage and trade capa-bilities for minerals • Defence industry does not require large volumes of CRM aside ammunitions	• Strengthens the ability to respond to short-term crises. • Other sectors might drive need for stockpiling mineral demand (piggyback).
Weaknesses	**Threats**
• It is technically difficult and financially costly to do on the national level • It is unclear which entity would be the primary responsible one • Lack of knowledge on dependence of specific minerals, including volume.	• It can introduce market inconsisten-cies and increase prices, Increase in protectionist behaviours

3.6. Develop programs for circularity for military systems as part of the Dutch National Raw Materials Strategy

Description: Implement circular initiatives for strategic components and materials from retired military systems, as a part of the circular agenda of the Dutch Raw Materials Strategy.

Anticipated effect: Reduced demand for raw materials, reduced supply vulnerabilities

Position in the supply chain: Refining, manufacturing, disposal

Responsible entities: EZ, MoD

Classification: Long term initiative

Strengths	Opportunities
• MoD has a high degree of control over maintenance/ disposal of defence systems • The National Programme on Circular Economy is well developed	• Develop synergies with the civil sector • Promotes circular economy
Weaknesses	**Threats**
• Recycling to retrieve CRM is not yet part of disposal of weapons systems • Materials don't go back into the system	• Security requirements might lead to increase in cost for disposal/recycling

4. Use procurement levers for supply chain resilience

4.1. Impose requirements for supply chain risk assessments for critical system manufacturers

Description: Impose requirements on critical system manufacturers to conduct periodic assessments of risks in the supply chain.

Anticipated effect: Increased supply chain resilience by reducing the dependency on sole sources; Strengthened early warning capacity in case disruptions

Position in the supply chain: From extraction to operation & maintenance

Responsible entities: MoD

Classification: Low hanging fruit, Enabler

Strengths	Opportunities
• Relative ease of implementation (requirements setting) • In the span of control of MoD • Capitalises on the knowledge, expertise and control of supplier base	• Supply chain analysis can be used to further optimise the supply chain beyond CRM related risks / dependencies
Weaknesses	**Threats**
• Highly dependent on the knowledge and expertise of system manufacturers • Particularly challenging for start-ups	• Price increases for systems • Burden on system manufacturers (time and resources) • Manufacturers might be reluctant to show vulnerabilities

4.2. Impose requirements for origin for critical system manufacturers

Description: Impose requirements on critical system manufacturers regarding the country of origin of critical components of their systems (e.g., by limiting the origin of the supplier base to EU/NATO)

Anticipated effect: Increased supply chain resilience: a supply chain that is more centred around reliable states ("friend-shoring")

Position in the supply chain: From manufacturing to operation & maintenance

Responsible entities: MoD, EU, NATO

Classification: Low hanging fruit

Strengths	Opportunities
• Relative ease of implementation (requirements setting); Within the span of control of MoD	• Enhances strategic autonomy, Supports European defence manufacturing base
Weaknesses	**Threats**
• Does not guarantee independence further upstream (CRM level); Imposing the requirements is relatively straightforward, but implementation by companies is costly	• Price increases for systems; The obligation placed on system manufacturers may lead to potential alterations in their way of working or supply chain structures; Could lead to an uneven playing field compared to other companies;

4.3. Impose requirements for circularity (R-ladder of strategies)

Description: Impose requirements for circularity to be accounted for in the design process of new defence systems

Anticipated effect: Reduced need for primary raw materials

Position in the supply chain: From manufacturing to disposal

Responsible entities: MoD

Classification: Low hanging fruit

Strengths	Opportunities
• Relative ease of implementation (requirements setting)	• New defence systems are and will be developed and acquired in the coming years where this requirement can be implemented
Weaknesses	**Threats**
• The priority in requirements setting is on operational effectiveness rather than recycling	• Delay in the development or deployment of new systems; Higher costs due to additional design requirements; The absence of an established recycling loop may limit the ability to fully benefit from intervention

4.4. Impose requirements to incorporate product passports for new systems

Description: Impose requirements when procuring new systems to develop and maintain a product passport.

Anticipated effect: Informed decision making through the provision of supply chain data; Well monitored stockpiling levels and needs

Position in the supply chain: From refining to disposal

Responsible entities: MoD

Classification: High investment high reward

Strengths	Opportunities
• Concept and software are available, pilot under development within MoD (Enginia)	• Enables a broad spectrum of other interventions • Could enhance public-private cooperation • Facilitates maintenance and recycling • Facilitates interoperability between systems and countries • Makes it easier to comply with regulations (e.g., conflict minerals, CSDDD) • Helps understand mechanical and chemical properties
Weaknesses	**Threats**
• Labor intensive and very costly to incorporate if done on all MoD weapon systems	• Price increases for systems; The obligation placed on system manufacturers may lead to potential alterations in their way of working or supply chain structures • Sensitivity of information can be a security threat

4.5. Impose diversification requirements for industry (components and systems)

Description: Impose requirements on/Incentivise the defence industry to diversify their supply base

Anticipated effect: Increased supply chain resilience by reducing the dependency on sole sources; Strengthened early warning capacity in case disruptions

Position in the supply chain: From manufacturing to operation & maintenance

Responsible entities: MoD

Classification: High investment high reward

Strengths	Opportunities
• Relative ease of implementation (requirements setting) • Within the span of control of MoD	• Creation of a broader industrial base; Can stimulate technological innovation to find alternatives
Weaknesses	**Threats**
• Alternatives for components and systems are not always readily available • High level expertise might be concentrated at few suppliers • Imposing the requirements is relatively straightforward, but implementation by companies is costly	• The market demand for systems may not be sufficient to sustain multiple competitors

4.6. Impose requirements for design and standardisation

Description: Encourage modular design, complexity reduction and product standardisation in defence systems

Anticipated effect: Simplifies repairs, increases supplier base

Position in the supply chain: From assembly to disposal

Responsible entities: MoD

Classification: Long term initiative

Strengths	Opportunities
• NATO and EU have existing technical standards frameworks in which this could be integrated • In the Netherlands, the NEN (Nederlands Normalisatie Instituut) has established a group on CRM standardisation	• Strengthens alignment within military partnerships (interoperability, interchangeability) • Reduces costs • Safeguards against other countries (outside of NATO) using standards to further geopolitical goals
Weaknesses	**Threats**
• Standardisation tends to be a slow and bureaucratic process	• Can spark competition between national industries rather than cooperation • Could lead to an uneven playing field if not done in cooperation with allies; IP sharing and proprietary interfaces pose a challenge

5. Expand the defence industrial base

5.1. Develop minimum manufacturing capacity for strategic components and systems

Description: Expand the ability to manufacture and supply strategic components and systems within trusted nations (for example EU/NATO).

Anticipated effect: Enhanced strategic autonomy; Broadened supply base; Increased support for industrial base

Position in the supply chain: From manufacturing to disposal

Responsible entities: EZ, EU, NATO

Classification: Long term initiative

Strengths	Opportunities
• Selected number of highly strategic components to focus on • Existing capacity within NATO	• Supports European and NATO strategic autonomy/self-sufficiency and domestic manufacturing base
Weaknesses	**Threats**
• Building greenfield capacity is very difficult and expensive	• The consolidation of manufacturing capabilities may not align with the policies of the national industrial base and local stakeholder interests.

5.2. Expand international defence production partnerships

Description: Work with partners and allies to strengthen supply security and derisk supply chains.

Anticipated effect: Broadened and diversified supply base

Position in the supply chain: From manufacturing to disposal

Responsible entities: EZ, EU, NATO

Classification: Long term initiative

Strengths	Opportunities
• NL can offer specific niche capacity, and it has existing good quality cooperation agreements and existing concrete operational initiatives (for example GE, UK, BE)	• Strengthens cooperation with like-minded countries
Weaknesses	**Threats**
• NL only has specific niche capacity	• Defence spending is budgeted nationally and partially focused on national industry • Possible diplomatic trade-offs (excluding some, including others)

[Confidential version only]

Annex 3. **Functional breakdown of the military platform – NLD Restricted**

[This Annex is provided as a separate document due to its classification]

[Confidential version only]

Annex 4. **Tier 1 supplier overview – NLD Restricted**

[This Annex is provided as a separate document due to its classification]

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