Berenschot

Dependencies, risks and measures regarding the use of critical raw materials within the Dutch Defence Industry Strategy areas

Final Report June 12th, 2024

Ministerie van Economische Zaken en Klimaat

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1. Management summary

Dependencies, risks and measures with regard to the use of critical raw materials within the Dutch DIS areas

Preface

- This report presents the results of the study into the dependencies, risks and measures on the use of critical raw materials within the Dutch Defence Industry Strategy areas.

- Geopolitical developments ensure an increased importance of Defence. Defence expenditures have risen sharply in, among other, Europe and the Netherlands, therefore increasing the demand for Defence equipment. Many critical raw materials identified by the European Commission, in processed form and incorporated into semi-finished products, are required for the production of Defence components and systems due to the high-performance requirements that usually cannot be guaranteed using civilian alternatives. In some cases, the mining and processing of these raw materials largely take place in third countries. Third countries are countries outside the European Union, except for the so-called European Economic Area countries (Norway, Liechtenstein and Iceland).

- Consulting firm Berenschot has conducted a study into critical raw materials within the Defence domain on behalf of the Ministry of Economic Affairs and Climate (EZK). EZK would like to have a deeper understanding of the dependence on raw materials, processing and supply chain that are mentioned within the Defence Industry Strategy (DIS). The ultimate goal is to prevent or reduce dependence on third countries in the mentioned DIS areas through a variety of actions.

- The following topics have been investigated with regard to the DIS categories:
  - The use of critical raw materials by companies in the defence industry.
  - The characteristics of the value chains with regard to production, purchasing and sales.
  - The dependencies of third countries on critical raw materials.
  - Country analysis and risk analysis of the supply chains.
  - Recommendations for the government and companies on how to mitigate risks.

- The research was conducted in close collaboration with the Ministry of Economic Affairs (EZK), the Ministry of Defence, various companies within the Dutch Defence industry and experts from TNO, RAND Europe, NLR, Clingendael and CBS.

- We would like to thank all participating organizations for their contribution to this study. We hope that the research provides good insight and guidance regarding the use of critical raw materials and the additional dependencies and risks within the DIS areas.

Executive summary (1/4)

Goals

- Consulting firm Berenschot has conducted research into critical raw materials within the Defence domain on behalf of the Ministry of Economic Affairs and Climate (EZK). EZK would like to have a deeper understanding of the dependence on raw materials, processing and supply chain that are mentioned within the Defence Industry Strategy (DIS). The goal of this study is to identify dependencies, assess how risky they are, and formulate mitigating measures to reduce risky dependencies.

Critical raw materials

- Companies in the Dutch defense industry indicate that the direct use of critical raw materials is limited. There is also little awareness about the subject.
- Few critical raw materials are purchased directly. Critical raw materials are processed within many components, alloys and composites that are purchased by Dutch companies. Components that contain critical raw materials are more important to companies than critical raw materials. Although the quantities of critical raw materials used are not large, the companies have indicated that they could be critical.
- The processing of the critical raw materials is not done directly by Dutch companies and/or their suppliers. The processing of raw materials is often further upstream in the value chain.
- Companies in the Dutch defense industry indicate that aluminium, copper, nickel, lithium and magnesium are most commonly used.
- Overall, companies are primarily dependent on critical raw materials for (high) technological applications. Critical raw materials are particularly relevant within electronics and semiconductors.

Value chains

- Dutch Defence and Security Industry (NLDTIB) sales are global. The NLDTIB is strongly export-oriented. A large share of Defence exports goes to the United States and Europe.
- The NLDTIB has strong international connections. 28% of NLDTIB companies have a foreign shareholder (also known as the 'ultimately beneficial owner', or UBO). This is the ultimate owner, a stakeholder, or the person who has control.
- The NLDTIB value chains are mainly located in Europe, Southeast Asia and the United States. Electronics and components are mainly imported from China and Asia.
- The Ministry of Defence's weapon systems are primarily imported from Europe and the United States. The major share of weapon systems supplied to The Netherlands originate from these countries and regions (81%).
- The equipment of the Dutch Air Force mainly comes from the United States (72% of aircrafts). Dutch Defence Industry companies active within the aerospace domain are also strongly internationally oriented.
- The equipment of the Dutch ground forces is much more spread to different countries, and especially Europe. The land domain uses more off-the-shelf products, civilian products and components. There is a lot of purchasing from Europe, little from Asia.

Management summary (2/4)

- Maritime platforms of the equipment at the Ministry of Defence mainly come from the Netherlands (89% of the defense equipment and 45% of vessels used). Companies in the maritime domain generally have a lot of freedom of choice regarding procurement, due to the high dual use character of ships. As a result, many alternatives are available.

Risks

- A major risk is the lack of insight into the value chains among companies. Direct suppliers are concentrated in Western Europe, the United States and Southeast Asia. Tier 1 and sometimes tier 2 are known to the companies, while the processing of critical raw materials into components often takes place further down the value chain. Companies have limited insight into where suppliers source the (sub)components and the critical raw materials incorporated into them.
- The aerospace domain and high-tech are dependent on a limited number of suppliers. There are few options to switch.
- There is strong dependence on China with regard to both the extraction (mining) and processing (processing) of the critical raw materials used.
- When looking at the use of critical raw materials and country risks, there are particular risks for the high-tech DIS areas and the aerospace domain.
- Companies indicate that the cost price is a much more important factor than shortages of certain materials, components and/or raw materials. Due to 'just-in-time' production, materials are kept in stock to a limited extent. China sometimes supplies materials below cost price, thereby gaining power and influence over the value chain.

Measures taken by companies

- Dual sourcing is commonly used. Most companies are reducing supply chain risks by expanding the number of suppliers, primarily to ensure delivery reliability.
- Reducing the use of critical raw materials is mainly in the context of lead time reduction and cost reduction. By using non-critical raw materials, potential supply risks can be reduced.
- Due to the limited use of critical raw materials and the fact that it is not always known which critical raw materials have been processed into components, companies are taking limited measures to reduce dependencies on critical raw materials. For example, OEMs often determine the standard (type of material, quality, production process, supplier), which leaves very limited room for switching to other suppliers. For example, the value chains of the aerospace domain are strongly focused on the United States. Making different choices regarding the use of critical raw materials is therefore complex.
- Research & Development is also important, in particular for the development of substitutes. However, there are few options for reuse and recycling, because the critical materials have been incorporated into components and the companies do not directly process these critical raw materials themselves.
- Stockpiling is less relevant due to limited direct use of critical raw materials. Companies generally want to reduce inventories because of just-in-time delivery.

Executive summary (3/4)

Measures taken by domain and DIS area

- The Dutch Ministry of Defence purchases many weapon systems directly from the United States. This makes these supply chains important. Knowledge and options for action are controlled mainly by American OEMs, while Dutch suppliers have little room to make other decisions regarding supply chains and critical raw materials. These Dutch companies, which are dependent on American supply chains, would like increased levels of transparency and insight into the supply chains.
- Within the aerospace domain, there is limited room for taking measures, especially due to the involvement of foreign OEMs. The land domain also takes limited measures due to the availability of substitutes, and primarily in favour of scaling up and product improvement. Within the maritime domain, limited measures are taken due to the limited use of critical raw materials and the dual-use nature of the industry, therefore multiple suppliers being available.
- High-tech products (including robotics and sensors) often have a more complex (critical) raw material mix. The semiconductor market is at the frontline of the raw materials discussion: the topic is important, there is more awareness, and more work is conducted related to the matter. Particularly with regard to securing supply chain risks and reducing the risk with regard to China. The companies of the defence-industry indicate that there is a desire for a stronger European electronics industry.

Recommendations for the government with regard to country collaborations

- Put the subject of critical raw materials higher on the EU-agenda and on NATO-level in line with the European Critical Raw Materials Act and the National Raw Materials Strategy. Also seek closer connections with the defence industry within the EU.
- Seek cooperation with other EU Member States and the industry for:
  - International research (at supply chain level) to reduce dependencies within the defence industry.
  - In joint European tenders, include the subject of critical raw materials in the tender rules/sustainability requirements.
  - Making agreements with the United States about possible solutions for ITAR-related complexity.
  - Explore opportunities to develop a closer relationship and improved cooperation with friendly European countries that mine and process critical raw materials, including Australia, Japan and South Korea.
  - Explore investments in mines within Europe or befriended third countries as agreed in the European Critical Raw Materials Act.

Recommendations for the Netherlands government with regard to restriction measures

- The various trade flows of critical raw materials and components in which they are processed need to be mapped more extensively, so that it becomes more transparent where vulnerabilities are present and any restrictive measures can be applied. This should preferably be carried out in an EU context. Negative effects must also be prevented, such as unnecessary trade barriers.

Executive summary (4/4)

- Conduct further investigation into the underlying ownership structures of the 'ultimate beneficial owner' of Dutch companies. The main question should be: who are the ultimate shareholders of the corporate level entities and what is their share?

Recommendations for the Netherlands government with regard to incentive measures

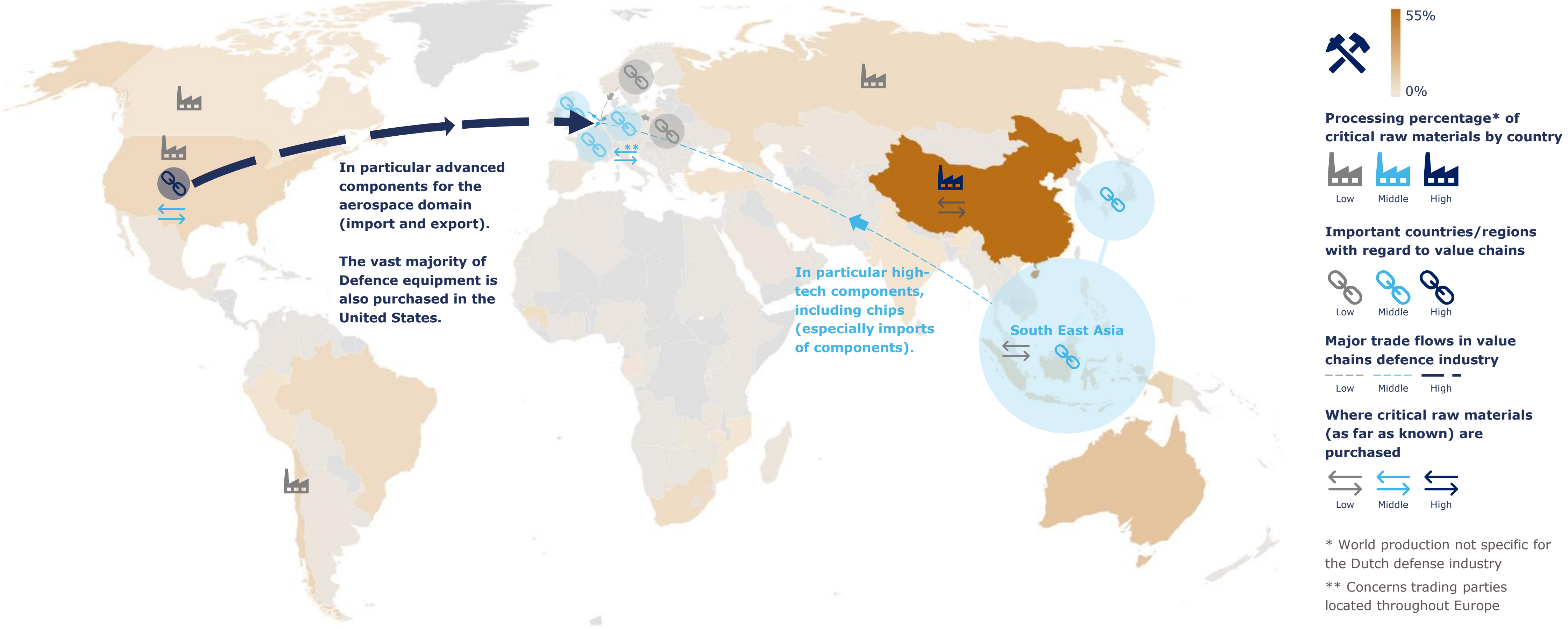
- Accept a geopolitical 'premium', or additional costs, to reduce strategic dependencies as a result of production in the Netherlands.
- Strengthening vulnerable supply chains where a major risk will arise if companies disappear or if scaling up is necessary. Use a programmatic approach in the value chain to guarantee security of supply and strengthen governance. Link the critical raw materials to the circular manufacturing industry implementation program.
- Focus on retaining and possibly attracting specific Defence-critical companies (to the Netherlands or the EU) and ensure their solid anchoring, so that there is more European control over the supply chain.

Action perspective with regard to companies

- Encourage collaboration within and between value chains to mitigate the risks of critical raw materials. Innovation clusters in which high-tech companies work together provide a relevant platform for joint research and development within the Netherlands, but also within Europe.
- In general, there is room for improvement when it comes to cooperation between the government and the Defence industry. Parties must learn to understand each other better and develop joint initiatives. Think about the long term.
- Encourage companies to gain insight into the supply chain and identify risks. Provide a deep dive on specific product groups in which the Netherlands has a leading role, such as in the maritime domain, and at high-tech product groups with a high risk, such as sensors and autonomous systems.
- Encourage companies to broaden the supply chain to reduce dependence on critical raw materials, for example support with certification of new suppliers.
- In line with the National Raw Materials Strategy stimulate research into substitutes, for example through advanced materials or alternative technologies, and innovations aimed at more efficient use of materials. These contribute to guaranteeing both strategic autonomy and leadership for Europe and the Netherlands at a global level.
- Analyse the supply chain risks regarding energetic materials and the role of the chemical supply chain. Energetic materials and other substances are used in a wide range of products such as propellants, explosives, pyrotechnics, gas generators and in industrial processes. Companies in the Netherlands can play a leading role in development of chemical substitutes.
- It is essential to get OEMs on board who have a leading role in the supply chain. This measure is difficult, especially in the aerospace domain, due to the dependence on foreign OEMs.

Overview of mining, processing and supply chains for critical raw materials in the Dutch Defence industry

- Shown are the main findings from this research. Mining and processing mainly take place in China; upstream value chains are mainly located in Western Europe, the United States, Southeast Asia and to a lesser extent the rest of Europe; the most important upstream value chain flows are from the United States and Southeast Asia. As far as it is known to Dutch companies, the purchasing of critical raw materials takes place in the United States, Europe and limited in Southeast Asia.



* World production not specific for the Dutch defense industry

** Concerns trading parties located throughout Europe

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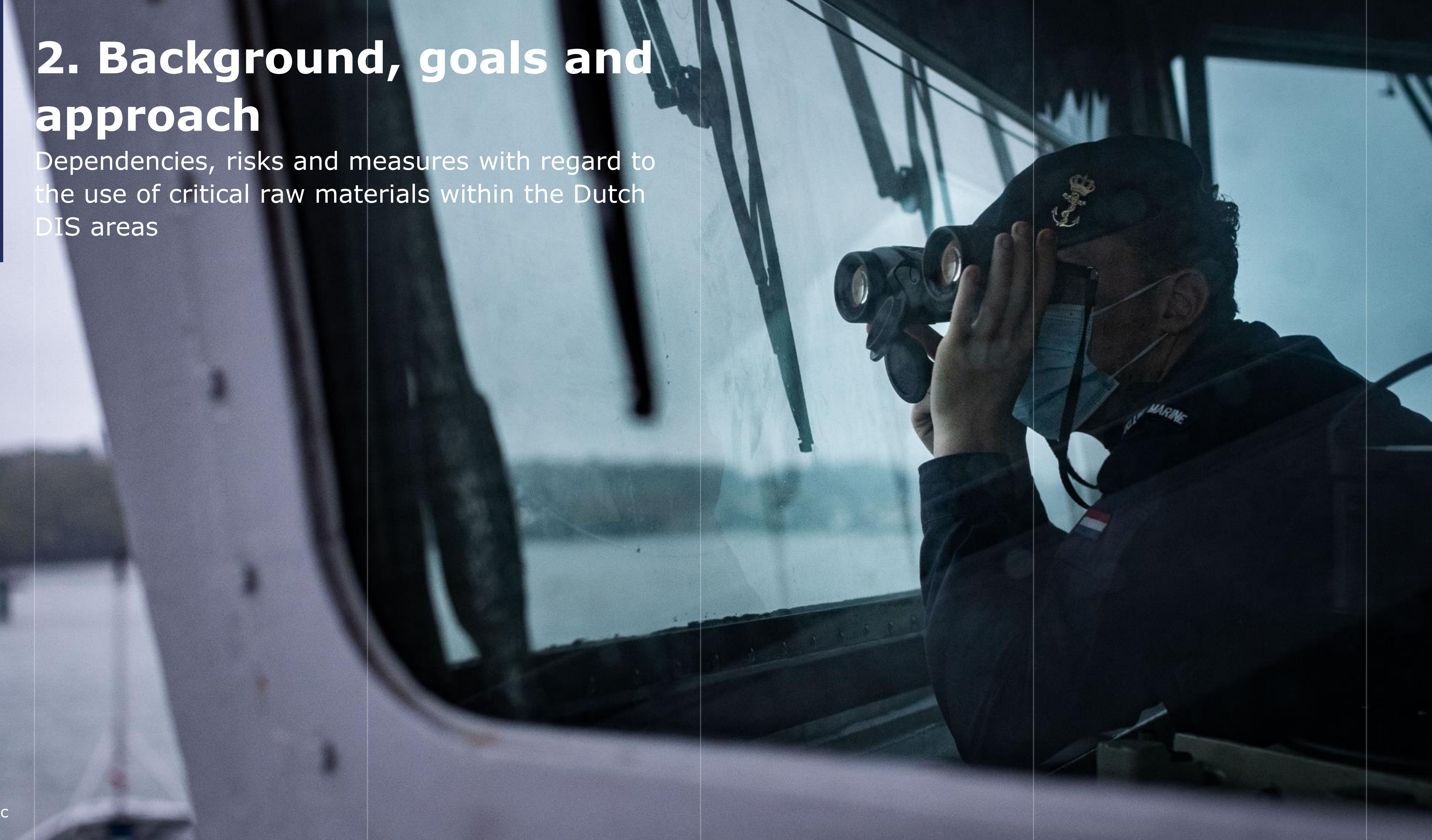
2. Background, goals and approach

Dependencies, risks and measures with regard to the use of critical raw materials within the Dutch DIS areas



Background

- Geopolitical developments have underlined the importance of robust and adaptive Dutch armed forces. The war in Ukraine, tensions around Taiwan and the South China Sea and the situation in the Middle East, among others, make the unstable and unpredictable geopolitical situation visible.
- Both the Netherlands and the European Union wish to be self-reliant due to these developments, especially when it comes to security. A stable base of knowledge, technology and industrial capabilities (as endorsed and described in the DIS) requires, among others, a robust and innovative Defence industry. A robust Defence industry requires continuity and security in supply chains, which are partly the result of minimal dependence on third countries. Third countries are all countries outside the EU, excluding so-called European Economic Area (EEA) countries (Norway, Liechtenstein and Iceland).
- A strong and sustainable supply chain of critical materials and raw materials is essential for the growth and competitiveness of the Dutch and European Defence industry.
- In the Netherlands, approximately 180,000 FTEs are employed by approximately 1,000 companies active in the Defence and security sector. Of these 180,000 FTEs, more than 22,000 FTEs are effectively working in the Defence and security sector. The total Defence and security-related turnover of these companies has risen sharply from €4.7 billion in 2021 to €7.7 billion in 2023. The sector is highly R&D intensive and export-oriented.
- Many raw materials are required for the production of Defence components and systems, both in processed form and processed into semi-finished products. Due to the high-performance requirements the use of civilian alternatives is not sufficient.
- The increase in production of renewable energy technology has led to a greater need for critical raw materials such as lithium, cobalt and rare earth metals, which are also needed for technologies required for the Dutch and European ambitions in the field of digitalization, Defence equipment and space.
- Global control over and access to critical raw materials is increasingly taking on a geopolitical dimension in addition to an economic one. Although Europe is a major buyer and therefore an important player in the supply chain, very little mining and processing of raw critical raw materials takes place in the region. That makes Europe vulnerable.
- The Dutch Ministry of Economic Affairs & Climate (EZK) has asked Berenschot to conduct a study into the dependence on raw materials, refining and supply chains within the categories identified within the Defence Industry Strategy (DIS).
- The research focuses on the product value chains and product categories relevant to the three DIS categories (knowledge, technologies and industrial capabilities) and areas within the capabilities (such as platforms and communication systems and services).

Goals

- The Ministry of Economic Affairs & Climate would like to have a deeper understanding of the dependence on raw materials, processing and supply chains within the categories (Knowledge, Technology and Industrial capabilities) identified within the Defence Industry Strategy (DIS).
- The goal of this research is to prevent or reduce risky dependencies on third countries in the mentioned DIS categories through an analyse of actions.
- The research question concerns making an analysis of the (critical) raw materials and production processes within the DIS categories (which is divided over the categories Knowledge, Technology and Industrial capabilities and the various domains). The emphasis is on dependencies on third countries in the use of these raw materials and production processes and their use in components and parts within these categories.
- After mapping the above, a risk analysis is carried out into the dependencies on third countries.
- Finally, recommendations have been drawn up on how to mitigate sensitivities, risks and/or dependencies, including a recommendation for an action perspective from the (national) government.

List of strategic (S) critical (K) raw materials 2023 (European Commission)		
Antimony (K)	Gallium (SK)	Nickel (SK)
Arsenic (k)	Germanium (SK)	Niobium (K)
Barite (K)	Hafnium (K)	Platinum metals (SK)**
Aluminium/Bauxite (SK)	Helium (K)	Scandium (K)
Beryllium (K)	Cobalt (SK)	Silicon metal (SK)
Bismuth (SK)	Copper (SK)	Strontium (K)
Boron (Sk)	Light rare earth* elements (K)	Tantalum (K)
Coking coal (K)	Lithium (SK)	Titanium metal (SK)
Fluorite (K)	Magnesium (SK)	Vanadium (K)
Phosphate rock (K)	Manganese (SK)	Feldspar (K)
Phosphorus (K)	Natural Graphite (SK)	Tungsten (SK)
		Heavy rare earth*** elements (SK)

List of critical raw materials according to the European Commission
source: https://www.rijksoverheid.nl

* Light rare earth elements (K): cerium, lanthanum, neodymium, praseodymium, samarium
** Platinum metals: iridium, palladium, platinum, rhodium, ruthenium
*** Heavy rare earth elements: dysprosium, erbium, europium, gadolinium, holmium, lutetium, terbium, thulium, ytterbium, yttrium

Research approach

1.Scoping	2. Desk research, quantitative research	3. Interviews and qualitative research	4.Strategic risk analysis/measures	5. Conclusions and reporting
• Start session • Project design • Definitions and scope • Products in scope • Planning • Communication	• Inventory of products • Value chains mapping • Quantitative research, using a survey for NLDTIB companies • Database research	• Further specification of value chains • Questionnaire and guidance • Interviews with the 25 most important companies and experts	• Analysis and interpretation of results • Risk analysis • Mitigating measures • Action perspective	• Prepare draft report • Assessment • Feedback on final report

Main question	Measurement indicators	Methodology/data sources
Analysis of the DIS per domain	• Land, aerospace, navy • Platforms • Value chains • Composition of products, components	• Berenschot NLDTIB-study, May 2022, 2024 • Strategic raw materials for Defence, Mapping European industry needs, January 2023 • JRC Science for Policy Report, 2016, 2023, 2024
Raw materials with regard to dependencies on third countries	• Critical raw materials • % dependency • Number of suppliers • Substitutes • Geopolitical score countries, country risks • Stock, world production	• UN Comtrade • CBS, OECD • http://www.grondstoffenscanner.nl • British Geological Survey (BGS) - World Mineral Production database • Critical Raw Materials Resilience - CRMS 2023 • Supply Chain Viewer of the EU Raw Materials Information System
Strategic analysis	• Risk analysis • Mitigating measures • Impact, probability	• Desk research • 25 interviews • Expert sessions

Steps from scope to action

Scope: define products

Within 3 DIS categories (knowledge, technology, industrial capabilities); Which products are involved for maritime, land, air/ space ?

NLDTIB: value chain analysis: understanding dependencies

Which supply chains belong to those products? Supply chains, players, production processes, technologies, logistics.	Which critical raw materials are used, in which links within the supply chain?	In which countries do the links in the supply chain take place? Divide countries into categories: the Netherlands, Europe, third countries.

Country and supply chain risk analysis

What risks are present?	What are the chances of it happening?	What is the impact on Defence in the Netherlands?

Action

What measures should be taken to mitigate the risks?	How can EZK monitor risks and dependencies in the future?

Research methodology

- The products, value chains and market have been mapped using desk research: budgets and investments from the Ministry of Defence, trends and developments, Berenschot databases and (customer) information, previous research and information provided by EZK.
- The project was supervised by employees from EZK and the Ministry of Defence, and a broader guidance group from the Ministry of Defence and TNO.
- In the Netherlands, there are approximately 1,000 companies active in the field of Defence and security-related technological industrial base (NLDTIB). These approximately 1,000 companies were invited to participate in the study by a questionnaire, of which 286 participated. This study is further referred to as NLDTIB.
- The following topics were surveyed:
  - To what extent the products are dependent on critical raw materials and components.
  - To what extent there is insight into the value chain of the suppliers (production locations, use of materials).
  - To what extent there is dependence on a limited number of suppliers with regard to critical raw materials / components.
  - Analyse of which strategic critical raw materials are relevant.
  - Analyse of the measures taken to reduce the risks with regard to critical raw materials.
- In addition, 25 in-depth interviews were conducted with various companies per domain within the Defence industry as well as with experts in the field of critical raw materials and materials.
- The risk inventory can be assessed on the basis of the bottlenecks with regard to the raw materials (number of suppliers, substitutes, total amount of reserves, shortages, innovations, recycling) and geopolitical bottlenecks (country of origin of the raw materials, country barriers, stability of the countries). When risks occur, there is an impact on Dutch Defence. The procurement plans of the Ministry of Defence may therefore come under pressure.
- The international part of the research was carried out in collaboration with international institute RAND Europe. RAND Europe is an independent not-for-profit institute for policy research with the aim of improving policy and decision-making.
- The assessment of the dependence of the Dutch Defence industry on third countries with regard to critical raw materials and specific critical materials consists of three steps. Firstly, desk research was carried out on datasets and publicly available sources of data on dependence on third countries for critical raw materials. This was followed by a qualitative analysis to identify the DIS areas that are sensitive to supply chain risks. Based on these activities, potential risks and challenges have been identified for the value chains of the Dutch Defence industry and risk-mitigating recommendations have been formulated.

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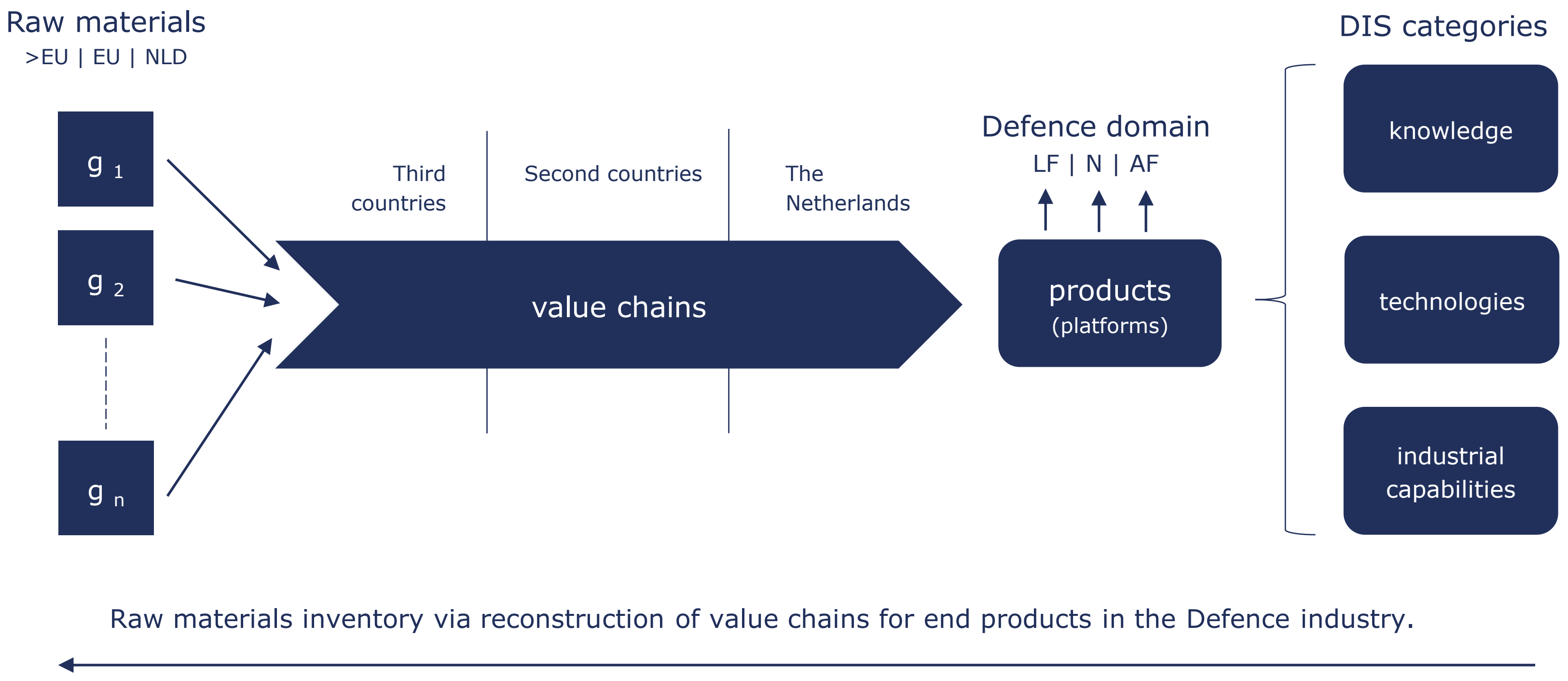
3. Scope

Dependencies, risks and measures with regard to the use of critical raw materials within the Dutch DIS areas

Research scope

- The research focuses on the value chains of products and product categories relevant to the three DIS categories (knowledge, technologies and industrial capabilities) and areas within the capabilities (such as platforms and communication systems and services). The Defence Industry Strategy (DIS), published in 2018, describes the basis that the Netherlands needs to be able to has its military act independently.
- It is studied to what extent the dominant technologies are dependent on critical raw materials and third countries. This concerns both Dutch companies and foreign companies that supply the Ministry of Defence.
- The domains studied are aerospace, land, maritime and security.

Framework for products, value chains and raw materials analysis



Source: Berenschot

Value chain analysis framework

- The analysis started from the companies that provide platforms. We look at the systems, components and semi-finished products that underlie them, whereby the link will be made with industrial capabilities and technologies (as defined in the DIS). We then identify where critical raw materials are used in these value chains and/or where there are dependencies on third countries.

Aerospace | Maritime | Land

Defence platforms
- Fighter plane
- Frigate
- Tank
- Radar
- Drone
- Satellites

Subsystems
- Airframe
- Drive
- Bridge
- Landing gear
- Wing

Components
- Engines
- Turbines
- Cabling
- Electrical components
- Sensors

Semi-finished products
- Interior parts
- Composite parts
- Sheet parts

Raw materials
- Alloys ferrous / non-ferrous
- Titanium
- Aluminium
- Natural Graphite

OEM → Tier 1 → Tier 2 → Tier 3 → Tier 4

SCOPE

Classification of DIS categories is the starting point of the study

- Industrial capabilities differ per domain. The dependence on raw materials will be less relevant for knowledge institutions and service providers, such as training and education.
- Classification from the DIS (platforms, communication systems/sensors, etc.): what are the dominant technologies and products in the DIS.
- Main weapon systems include among other ships, aircraft and tanks.

Industrial capabilities % NL companies, more than 1 answer possible	Maritime	Aerospace	Land
Platforms (the main weapon systems)	29%	48%	23%
Observation and Information Gathering Systems, Services	21%	11%	28%
Information, decision making, Command & Control systems	17%	20%	30%
Communications systems and services	18%	26%	27%
Weapon systems, ammunition and platform protection	25%	33%	23%
Training and education	32%	17%	19%
Material-Logistics support	49%	37%	41%
Combat Service Support (support for operations)	13%	20%	21%
Transport systems and services	12%	17%	29%
Cyber	12%	11%	15%

Technology % NL companies, more than 1 answer possible	Maritime	Aerospace	Land
Simulation and virtualization	29%	21%	22%
Artificial intelligence	20%	26%	27%
Sensors (incl.quantum and nano sensors)	16%	14%	27%
Robotics and autonomous systems	25%	21%	25%
3D printing and new materials	16%	21%	18%
Human-System Integration	17%	19%	20%
Cyber, electromagnetic analysis, quantum computing	15%	14%	17%
Space / satellites	12%	21%	5%
Human enhancement	7%	5%	8%
Directed energy weapons	4%	2%	3%
Biotechnology	0%	0%	2%

Knowledge areas % NL companies, more than 1 answer possible	Maritime	Aerospace	Land
Defence analysis	11%	5%	6%
Material readiness & logistics	32%	36%	32%
Personnel readiness & human performance	14%	7%	12%
Command & control	20%	11%	27%
Situational awareness	24%	16%	24%
Protection	22%	14%	23%
Weapon characteristics, performance & effects	12%	16%	11%
Platform characteristics, performance & effects	20%	18%	13%
Network infrastructure and cyber security	17%	14%	20%
Legal, ethical and moral implications	5%	0%	4%

DIS groups with a potentially high impact with regard to critical raw materials within NLDTIB.

DIS groups where NLDTIB are less active, but with an impact of critical raw materials.

Distribution of activities of Defence industry companies within the industrial capabilities from the DIS

Source: Berenschot NLDTIB (2024)

4. Critical raw materials

Dependencies, risks and measures regarding the use of critical raw materials within the DIS domains

Public

The starting point is the 34 critical raw materials list as determined by the European Commission

- Since 2011, the European Commission has published which raw materials are considered critical every three years. This is determined on the basis of the economic importance and the supply risk. The most recent list was published in 2023, where, after a shortlist of 70 potential critical raw materials (67 individual raw materials, three material groups), 34 raw materials were determined as strategic or critical.
- The aim of compiling this list is to create awareness, strengthen the European (industrial) competitive position, stimulate (efficiency) production and recycling and create relevant policy, according to the European Commission.
- With regard to the processing and use of (critical) raw materials, a distinction is made between the different phases upstream, midstream and downstream. Thousands of actors are involved within and between these phases, including traders, service providers and storage and transport parties (HCSS, 2023).

List of strategic (S) critical (K) raw materials 2023 (European Commission)		
Antimony (K)	Gallium (SK)	Nickel (SK)
Arsenic (k)	Germanium (SK)	Niobium (K)
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Phosphorus (K)	Natural Graphite (SK)	Tungsten (SK)
		Heavy rare earth elements (SK)

Upstream (mining/extraction)
The extraction (mining) of raw raw materials.

→

Midstream (conversion/processing)
Processing materials into the desired form.

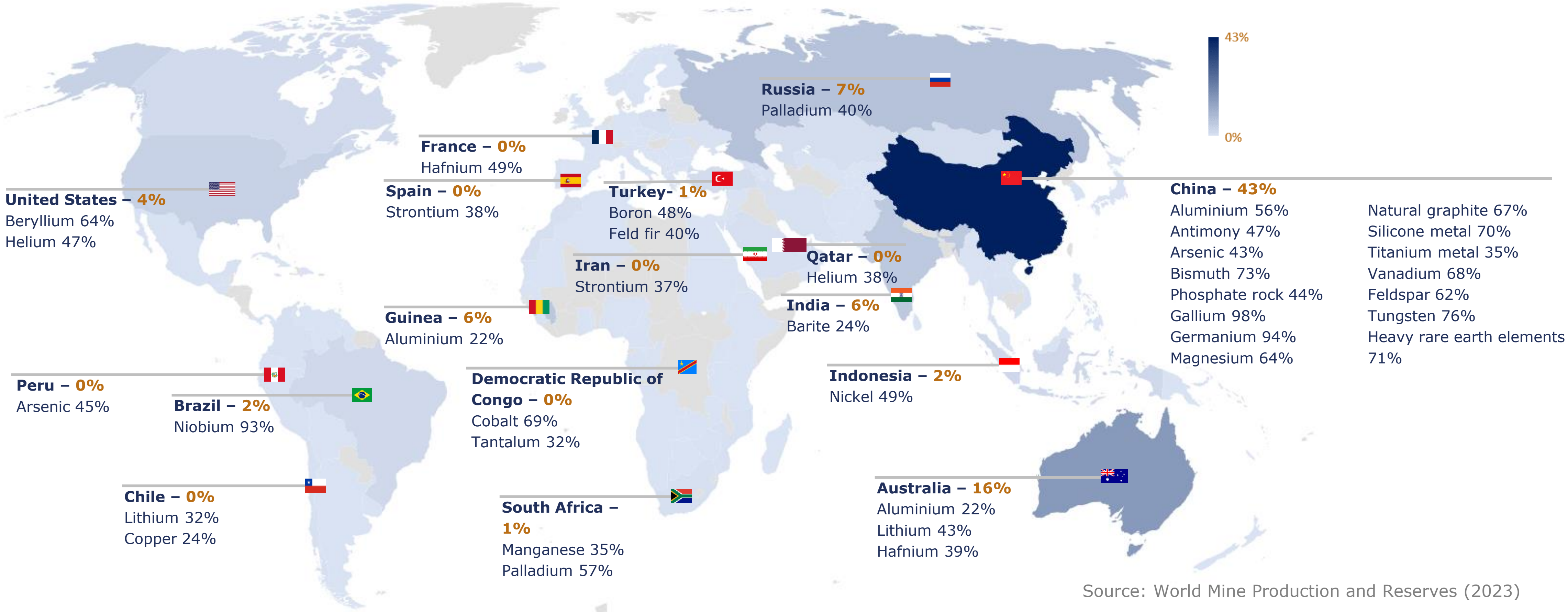
→

Downstream
The actual production of components in which the (processed) (critical) raw materials are processed, as well as consumption and recycling.

CRITICAL RAW MATERIALS

Only 3% of the total volume of critical raw materials is mined in Europe

- The mining of critical raw materials largely takes place in China and Russia. But a very limited share of total world production originates from Europe.
- The figures in the graph concern total world production, not production specifically for the Defence industry.
- The colour intensity and the percentage in indicate the global share in the extraction of critical raw materials per country. It also indicates per country what the most mined critical raw materials are, and the share of these most mined critical raw materials compared to the total global mined volume of that critical raw material.



Source: World Mine Production and Reserves (2023)

Mining and processing primarily takes place in China

- Shown is the percentage of mining and processing per critical raw material by continent, with China and Russia specifically highlighted.
- The majority of both mining and processing takes place in China.
- Cobalt mainly originates from China-controlled mines in Congo.
- To reduce dependence on other countries, the European Union wants to produce more critical raw materials domestically in the first place.
- The European target is to extract 10% of the required critical raw materials in Europe by 2030, process 40% and recycle 15%. In addition, the EU also wants to avoid importing more than 65% of a given raw material from a single country.

	Mining %									Processing %								
Critical raw material	China	Russia	Europe	North America	Africa	Australia	Asia	Central America	South America	China	Russia	Europe	North America	Africa	Australia	Asia	Central America	South America
Aluminium/Bauxite (SK)	25%	22%	17%	2%	1%	2%	23%	7%	1%	55%	3%	17%	6%	6%	7%	3%	2%	0%
Copper (SK)	9%	4%	12%	4%	12%	5%	16%	37%	2%	38%	2%	18%	4%	6%	12%	6%	12%	2%
Nickel (SK)	3%	11%	61%	7%	5%	2%	3%	4%	4%	35%	6%	24%	7%	7%	11%	3%	5%	2%
Lithium (SK)	17%	43%	0%	0%	0%	0%	1%	38%	0%	56%	0%	0%	0%	1%	0%	0%	43%	0%
Magnesium (SK)	64%	3%	2%	5%	2%	17%	0%	6%	0%	91%	0%	2%	2%	3%	0%	0%	2%	0%
Titanium metal (SK)	35%	6%	6%	0%	8%	5%	39%	1%	0%	43%	0%	33%	20%	0%	4%	0%	0%	0%
Cobalt (SK)	1%	5%	10%	5%	2%	2%	73%	0%	2%	60%	3%	3%	2%	5%	20%	6%	0%	0%
Manganese (SK)	4%	15%	9%	0%	1%	2%	65%	3%	0%	58%	1%	23%	2%	0%	10%	2%	2%	1%
Tungsten (SK)	76%	0%	15%	2%	0%	2%	2%	2%	0%	86%	0%	5%	3%	4%	2%	0%	0%	0%
Vanadium (K)	68%	0%	0%	18%	0%	0%	8%	6%	0%	70%	0%	6%	10%	0%	0%	9%	5%	0%
Boron (Sk)	6%	0%	1%	2%	22%	48%	0%	22%	0%	3%	0%	1%	2%	25%	49%	0%	20%	0%
Beryllium (K)	27%	0%	0%	0%	64%	0%	9%	0%	0%	8%	0%	42%	0%	50%	0%	0%	0%	0%
Germanium (SK)	94%	0%	1%	4%	1%	0%	0%	0%	0%	83%	0%	2%	5%	2%	8%	0%	0%	0%
Silicon metal (SK)	70%	1%	3%	7%	4%	9%	1%	5%	0%	76%	0%	0%	2%	2%	13%	0%	7%	0%
Tantalum (K)	5%	2%	0%	1%	0%	1%	69%	20%	0%									
Helium (K)	1%	3%	38%	3%	49%	1%	6%	0%	0%	0%	3%	30%	2%	56%	1%	8%	0%	0%
Platinum metals (SK)	1%	0%	0%	25%	9%	1%	65%	0%	0%	1%	0%	0%	26%	11%	1%	61%	0%	0%
Antimony (K)	47%	3%	27%	5%	1%	13%	0%	4%	0%	52%	0%	24%	0%	1%	19%	0%	3%	1%
Gallium (SK)	98%	0%	1%	1%	0%	0%	0%	0%	0%	94%	0%	2%	2%	0%	2%	0%	0%	0%
Heavy rare earth elements (SK)	71%	6%	7%	1%	14%	0%	1%	1%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%
Natural Graphite (SK)	67%	0%	8%	1%	1%	2%	16%	5%	0%									
Bismuth (SK)	73%	0%	25%	0%	0%	0%	0%	2%	0%	70%	0%	24%	0%	0%	4%	0%	1%	1%
Light rare earth elements (K)										85%	0%	13%	2%	0%	0%	0%	0%	0%
Strontium (K)	23%	0%	32%	0%	6%	38%	0%	0%	0%									
Arsenic (k)	43%	0%	0%	1%	0%	2%	10%	45%	0%	44%	0%	0%	1%	0%	2%	12%	40%	0%
Feldspar (K)	6%	0%	34%	1%	2%	51%	2%	2%	0%									
Niobium (K)	0%	0%	0%	0%	6%	0%	1%	93%	0%	0%	0%	0%	0%	11%	0%	0%	89%	0%
Phosphorus (K)										79%	0%	11%	0%	11%	0%	0%	0%	0%
Scandium (K)										67%	0%	8%	17%	4%	4%	0%	0%	0%
Hafnium (K)	11%	39%	5%	0%	8%	0%	38%	0%	0%	3%	0%	0%	3%	44%	51%	0%	0%	0%
Barite (K)	24%	0%	41%	3%	11%	6%	14%	1%	0%									
Coking coal (K)	53%	16%	9%	10%	8%	2%	1%	1%	0%	70%	0%	12%	7%	2%	8%	0%	0%	0%
Fluorite (K)	62%	0%	8%	1%	20%	3%	5%	0%	0%									
Phosphate rock (K)	44%	0%	14%	8%	8%	1%	20%	5%	0%									

Source: World mining data (2023)

CRITICAL RAW MATERIALS

Total world production and reserve quantities

- For each critical raw material the available world volume, production, stockpiling by the US government, the arithmetic remaining lifespan (calculated by the reserve stock divided by production), price volatility and the EU end-of-life recycling input rate are shown.
- It should be considered that some materials are made as a by-product, as such there is currently no direct stock available.

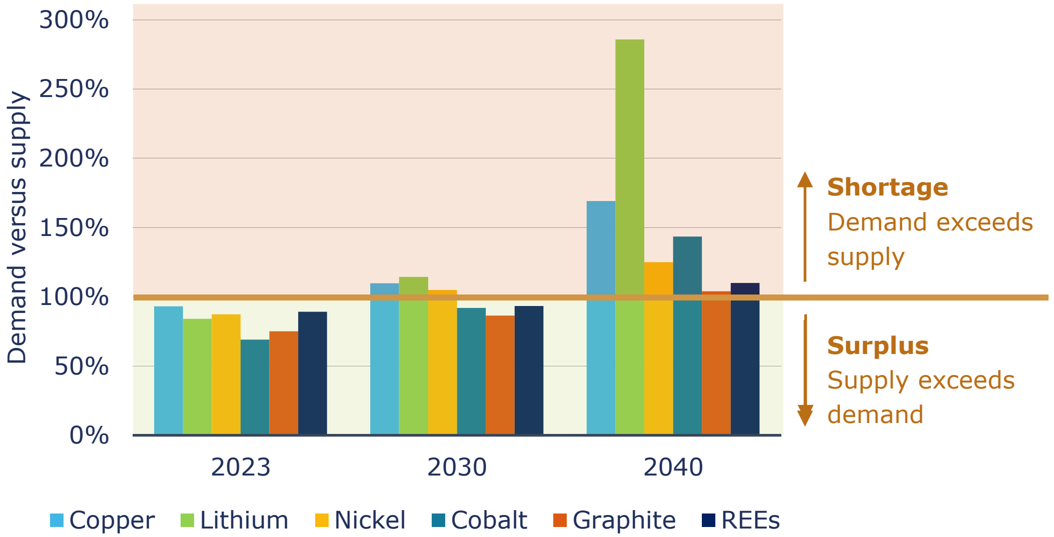
Critical raw material	Global reserves volume (tonnes)	World production	US Government Stockpile	Remaining lifespan	Price volatility	EU End of life recycling input rate
Aluminium/Bauxite (SK)	55,000,000,000	465,579,588	Yes	118	134%	32%
Copper (SK)	2,100,000,000	22,225,410	No	94	181%	55%
Nickel (SK)	350,000,000	3,248,896	Yes	108	164%	16%
Lithium (SK)	105,000,000	345,829	No	304	109%	0%
Magnesium (SK)	13,000,000,000	26,695,729	No	487	161%	13%
Titanium metal (SK)	690,000,000	8,942,994	Yes	77	52%	30%
Cobalt (SK)	25,000,000	166,030	Yes	151	111%	22%
Manganese (SK)	1,900,000,000	20,284,488	Yes	94	392%	9%
Tungsten (SK)	4,400,000	85,926	Yes	51	158%	42%
Vanadium (K)	63,000,000	115,271	No	547	171%	6%
Boron (Sk)		5,346,091	No		117%	1%
Beryllium (K)	100,000	6,803	Yes	15	82%	0%
Germanium (SK)		139	Yes		158%	2%
Silicon metal (SK)		8,583	No		58%	0%
Tantalum (K)	390,000	1,726	Yes	226	135%	1%
Helium (K)	31,300	158	Yes	198		2%
Platinum metals (SK)	100,000,000	183,022	Yes	546	145%	12%
Antimony (K)	2,000,000	83,031	Yes	24	131%	28%
Gallium (SK)	1,100	616	No	2	141%	0%
Heavy rare earth elements (SK)	110,000,000	296,837	Yes	371		1%
Natural Graphite (SK)	280,000,000	1,727,486	No	162	42%	3%
Bismuth (SK)		10,276	No			0%
Light rare earth elements (K)						1%
Strontium (K)	1,000,000,000	342,700	No	2918	170%	0%
Arsenic (k)	1,128,080	56,404	No	20		0%
Feldspar (K)	2,294,000,000	39,519,883	No	58	121%	1%
Niobium (K)	17,000,000	118,209	Yes	144	108%	0%
Phosphorus (K)						0%
Scandium (K)			No		180%	0%
Hafnium (K)	74,000	1,290	Yes	57		0%
Barite (K)	2,000,000,000	8,278,342	No	242		0%
Coking coal (K)		1,041,883,724				0%
Fluorite (K)	5,000,000,000	9,236,417	No	541	51%	1%
Phosphate rock (K)		70,787,780	No		134%	0%

Source: United States Geological Survey Mineral commodity summaries 2024

Production shortages are expected, especially for copper and lithium

- Shown is the ratio between the expected global total production demand excluding recycling versus the expected global total production supply for 2023, 2030 and 2040 of a selection of critical raw materials.
- Current forecasts lead to production shortages for copper, nickel, cobalt and especially lithium by 2040.
- Production can only keep up with the rapidly increasing demand to a limited extent. There are several reasons why production cannot keep up with the rapidly increasing demand. This is often because price volatility of raw materials limits investments in, for example, new mining.
    - Copper: there is a shortage of new projects and investments in the current facilities, facilities are also being closed due to protests or there is limited investment in them.
    - Lithium: price volatility is causing projects that are in the pipeline to be delayed. Investing therefore becomes less attractive, especially for the European Union and the United States, where projects are relatively more expensive.
    - Nickel: due to low prices, producers/suppliers take cost measures, which means that production does not keep up with demand.
    - Cobalt: price pressure leads to fewer investments. Stock is also declining in the Democratic Republic of Congo, where most of the world's cobalt production takes place.

Supply and demand ratio of selection critical raw materials



Critical raw material	Supply and demand (in kilotons)	2023	2030	2040
Copper	Demand	21,409	25,249	25,373
	Supply	23,000	23,000	15,000
Lithium	Demand	160	503	1172
	Supply	190	440	410
Nickel	Demand	3,061	4,615	5,625
	Supply	3,500	4,400	4,500
Cobalt	Demand	166	299	323
	Supply	240	325	225
Graphite	Demand	4,324	9,086	13,535
	Supply	5,750	10,500	13,000
Self-earth metals (REEs)	Demand	67	98	121
	Supply	75	105	110

Source: Global Critical Minerals Outlook 2024 (International Energy Agency, IEA)

Very limited imports of critical raw materials into the Netherlands

- Shown is the total Dutch imports (direct and indirect) in millions of euros. Data for aluminium/bauxite, light rare earth elements and scandium are missing.
- There is very limited direct import by the Netherlands of critical raw materials.
- Copper, nickel and coking coal are imported the most.

Critical raw material	Total direct imports (mio euros)	Total indirect imports NL (direct and indirect) for all sectors (million euros)	Total imports NL (million euros)
Aluminium/Bauxite (SK)			
Copper (SK)	0	540.3	540.3
Nickel (SK)	425	148.1	573.1
Lithium (SK)	12	21.8	33.8
Magnesium (SK)	28	20.3	48.3
Titanium metal (SK)	28	39.8	67.8
Cobalt (SK)	8	89.1	97.1
Manganese (SK)	82	58.0	140.0
Tungsten (SK)	5	18.8	23.8
Vanadium (K)	24	9.0	33.0
Boron (Sk)	0	17.0	17.0
Beryllium (K)	0	9.2	9.2
Germanium (SK)	0	4.9	4.9
Silicon metal (SK)	83	43.0	126.0
Tantalum (K)	0	1.5	1.5
Helium (K)	0	14.5	14.5
Platinum metals (SK)	25	242.4	267.4
Antimony (K)	9	8.7	17.7
Gallium (SK)	0	1.8	1.8
Heavy rare earth elements (SK)	0	7.7	7.7
Natural Graphite (SK)	10	11.3	21.3
Bismuth (SK)	0	2.2	2.2
Light rare earth elements (K)			0.0
Strontium (K)	3	3.2	6.2
Arsenic (k)	0	4.2	4.2
Feldspar (K)	3	3.7	6.7
Niobium (K)	5	9.7	14.7
Phosphorus (K)	12	12.1	24
Scandium (K)			0.0
Hafnium (K)	0	1.8	1.8
Barite (K)	33	14.4	47.4
Coking coal (K)	1436	473.1	1,909.1
Fluorite (K)	0	49.1	49.1
Phosphate rock (K)	79	77.1	156.1

Source: CBS - Critical materials in the Dutch supply chain

Limited but essential use of critical raw materials in Defence applications

Relatively limited research has been conducted into the use of critical raw materials within Defence applications as well as into the Dutch Defence industry. In particular, the studies by the Joint Research Center (JRC) and the Hague Center for Strategic Studies (HCSS) specifically address these, although they do not specifically focus on material use in the Netherlands.

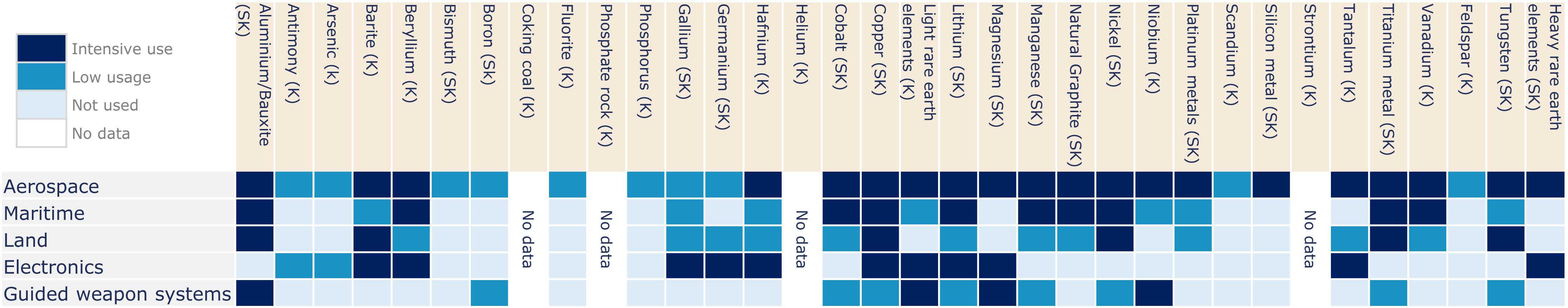
- Different materials are combined in the form of alloys (mixtures of metals with chemical elements, which can contain up to a dozen materials) and composites (composite materials). Most Defence applications integrate a large number of semi-finished and finished products made from different alloys, composites and almost none of them are made from a single raw material or raw material.
- Many raw materials, processed and semi-finished products are indispensable for the production of Defence components and systems due to the high-performance requirements that usually cannot be guaranteed using conventional substitutes.
- The dependence on a critical raw material varies per domain.
- Although many different critical raw materials are used in Defence applications, in general the total amounts used in the defence industry are rather small compared to the civilian domain.
- Thus, the risk to the Defence industry is not necessarily the availability of raw materials and material in large quantities, but rather the availability of raw materials and material of the required quality and required composition.

High frequency of use of critical raw materials within the aerospace domain, but limited in the maritime domain

Land
A high number of critical materials are used in the land domain, which is quite broad (tanks, panther vehicles, artillery, ammunition and (fire) weapons). Beryllium is used for tank platforms and electronic systems. Graphite for ammunition, aluminium for radar systems and navigation systems, copper for on-bard electronics (navigation, communications) and vanadium and titanium for weapons and cannons.

Aerospace
Almost all critical raw materials are used. Aluminium, natural graphite, copper and titanium are used for the frame (including the body, wings and tail), titanium for sensors and optical systems and copper for optical systems. Beryllium and nickel are used, among other things, for the landing gear and electronic systems.

Maritime
A limited number of critical raw materials are used within the maritime domain. In particular, aluminium, graphite, nickel, titanium, copper and lithium are used for platforms. Graphite is primarily used for on-board electronics, nickel for turbines, titanium for platform parts and navigation systems, copper for engines and lithium for batteries and electrical systems.



Sources: JRC (2016) & HCSS (2023)

5. Analysis of value chains and critical raw materials NLDTIB

Dependencies, risks and measures with regard to the use of critical raw materials within the Dutch DIS areas

Companies in the aerospace domain in particular indicate that it is dependent on critical raw materials

Aerospace

- Companies within the aerospace domain indicate that highly processed and high-quality materials are frequently used. Both production and manufacturing processes make extensive use of critical raw materials.
- Interviews show that relatively high levels of alloys (or those containing many chemical elements) are used.

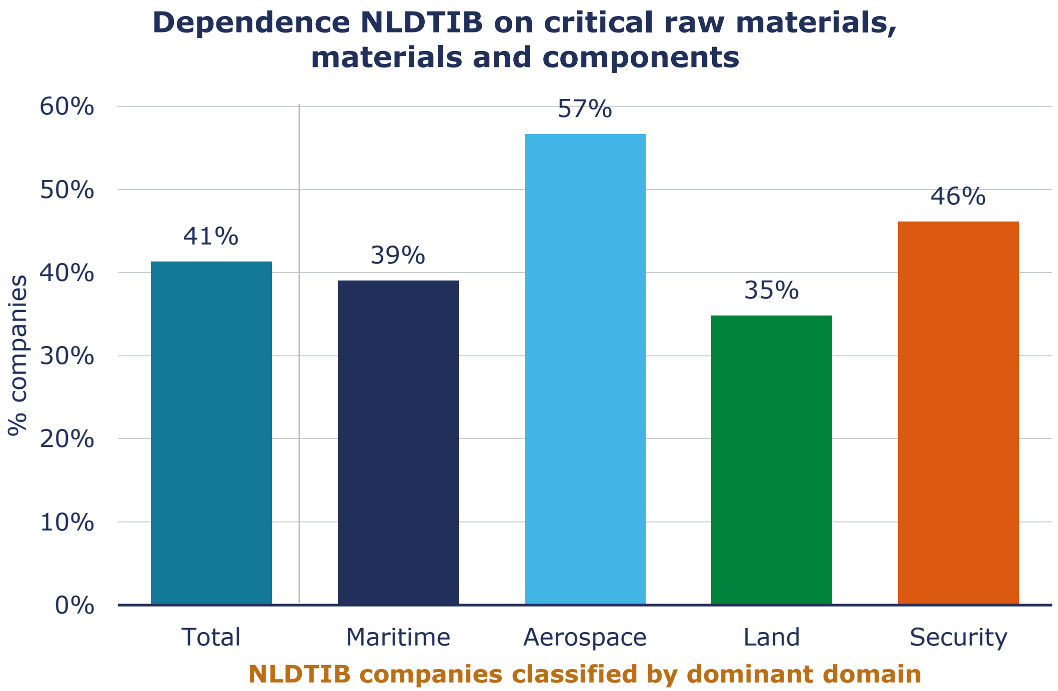
Land

- Within the land domain, critical raw materials are used more restrictively, and there is also more use of off-the-shelf products. Many civilian components are also used, for example for clothing and vehicles. However, critical raw materials and materials are used more for specific applications, such as armour steel or the powertrain of heavy vehicles. Critical raw materials are also used in production processes.
- Within the land domain, there is relatively the least reliance on critical raw materials.

Maritime

- Critical raw materials are used to a relatively limited extent within the maritime domain. This concerns critical raw materials for the construction of the platform (which are somewhat complex). Critical raw materials are also used in the production of certain alloys and composites.

- The security domain includes organizations such as cyber companies.
- In every domain, many critical raw materials are used for (high) technology applications, such as sensors and communication tools. These include chips.

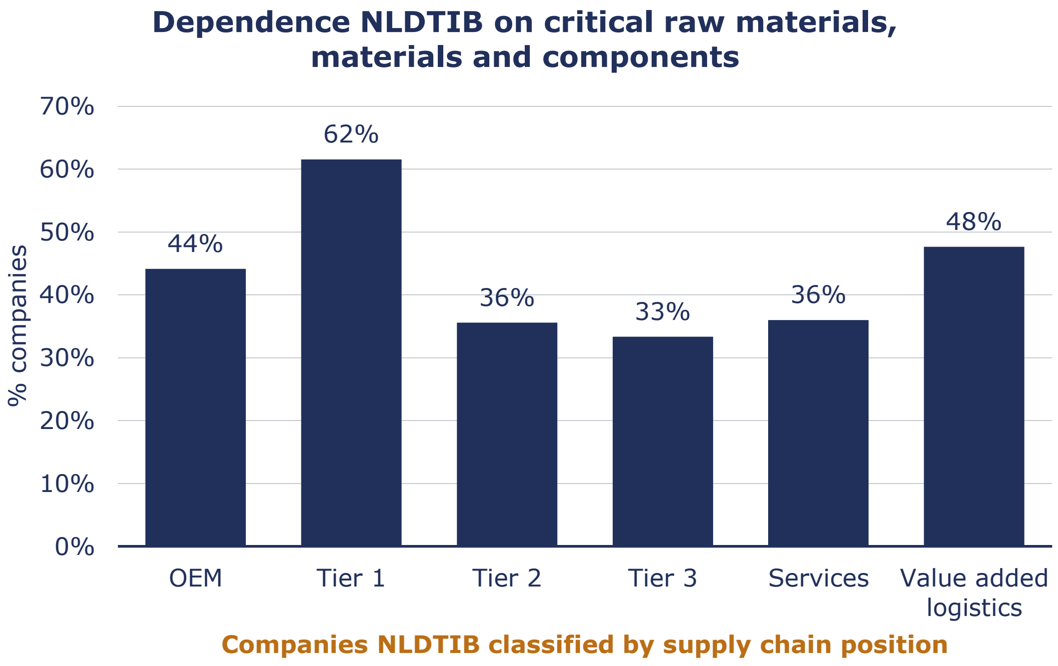


Source: NLDTIB Berenschot, 2024

Critical raw materials are processed into components purchased by the Dutch Defence companies

- Companies buy limited critical raw materials themselves. These are largely incorporated in the (sub)components that are purchased. Consequently, companies do not always know whether and in what quantities critical raw materials are used or incorporated in components and products.
- Since critical raw materials are not purchased directly but are processed in (sub)components, they are more often critical components (components that include critical raw materials) than critical raw materials.
- Critical raw materials are particularly processed in (high-)technological applications. This particularly concerns semiconductor. The dependence on high-performance electronics applies to all domains. Highly processed and high-quality raw materials are also frequently used within defence applications, such as for armour steel or complex composite compounds.
- Critical raw materials are also used in the processing of these raw materials, components, alloys and composites.
- The processing of critical raw materials is not done by Dutch companies and/or their suppliers. The processing of critical raw materials is often further upstream in the chain.
- The quantities of critical raw materials used are limited. Nevertheless, in many cases they are critical to the component or product and few alternatives and substitutes are available.
- Finally, there is little awareness of the issue, which is due to the very limited direct use and sourcing of critical raw materials.

- In the graph below, the NLDTIB companies have indicated the extent to which they are dependent on critical raw materials, materials and components. The companies are classified according to the supply chain position they have indicated.
- Tier 1 companies are most dependent on critical raw materials compared to other companies in the supply chain. Value added logistics mainly includes trading companies such as raw material traders.

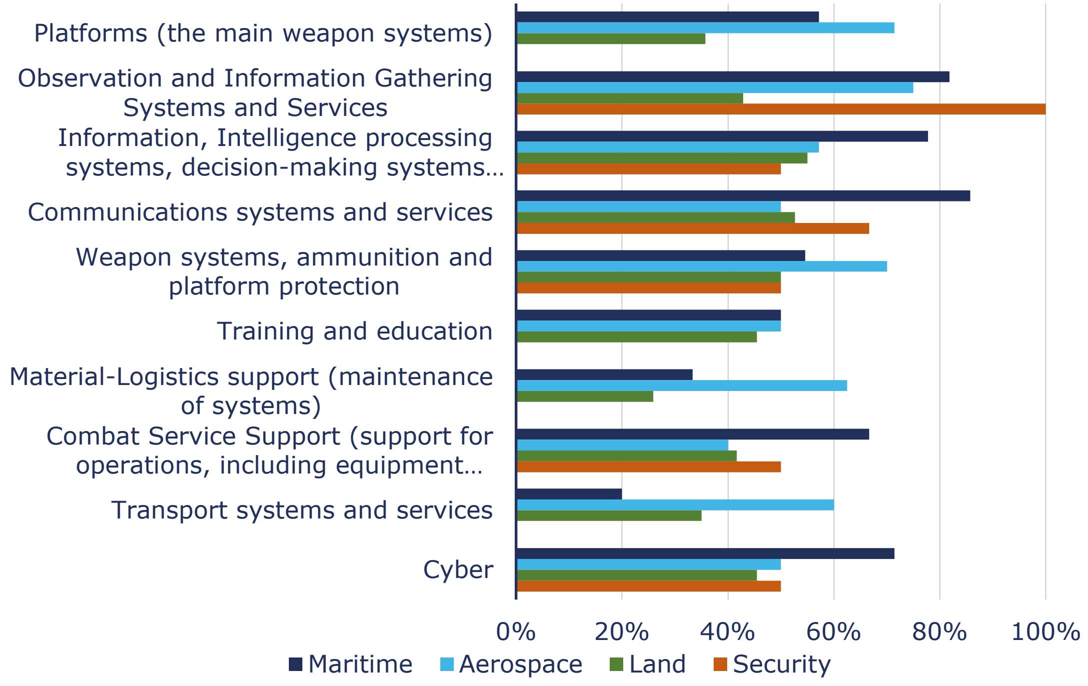


Source: NLDTIB Berenschot, 2024

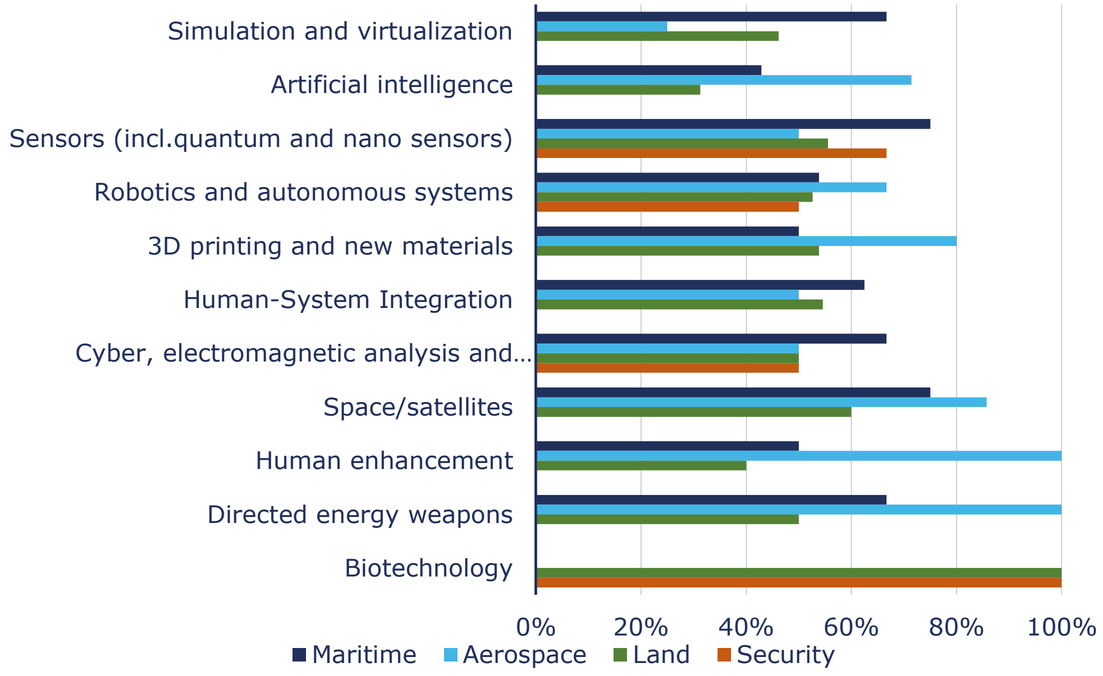
There is greater dependence on critical raw materials in high tech DIS areas

- Companies were asked within which DIS domains they operate.
- Overall, there is dependence on observation and information gathering systems and services, communication systems and services and weapon systems, munitions and platform protection.
- For aerospace and, to a lesser extent maritime, there is also dependence on critical commodities within platforms.
- Within sensors, robotics and autonomous systems, 3d printing, space/satellites and directed energy weapons there is a higher dependence on critical raw materials.
- For the aerospace domain, there is a higher dependence with respect to AI and human enhancement.

Dependence NLDTIB on critical raw materials, materials and components



Dependence NLDTIB on critical raw materials, materials and components

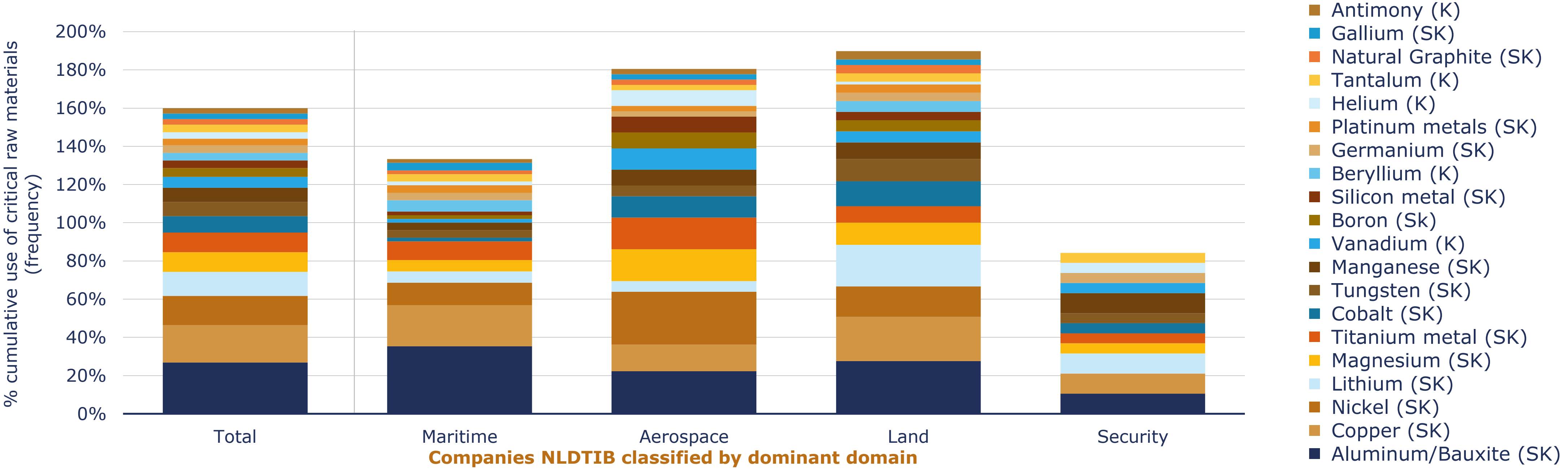


Source: NLDTIB Berenschot, 2024

Aluminium/Bauxite, copper, nickel and lithium are most commonly used in components and products

- Companies were asked which critical raw materials are incorporated in products or (sub)components. This is not about quantities, but about the frequency per company whether the material is used.
- Aluminium/Bauxite, copper, nickel and lithium are processed most frequently according to the companies.
- Magnesium and titanium metal are specifically mentioned in the aerospace domain.
- From the interviews we conclude that aluminium has very limited direct use. It is mainly used in certain alloys and composites, in combination with other critical raw materials, such as manganese and nickel.
- Compared to previous studies, a similar picture can be seen: in particular, aluminium, copper and nickel are frequently used. However, cobalt, barite and beryllium are mentioned more restrictively, as well as lithium in marine and aerospace applications. Production of components incorporating these critical raw materials may not take place in the Dutch defence industry.

Critical raw materials that are processed into products and/or (sub)components within NLDTIB



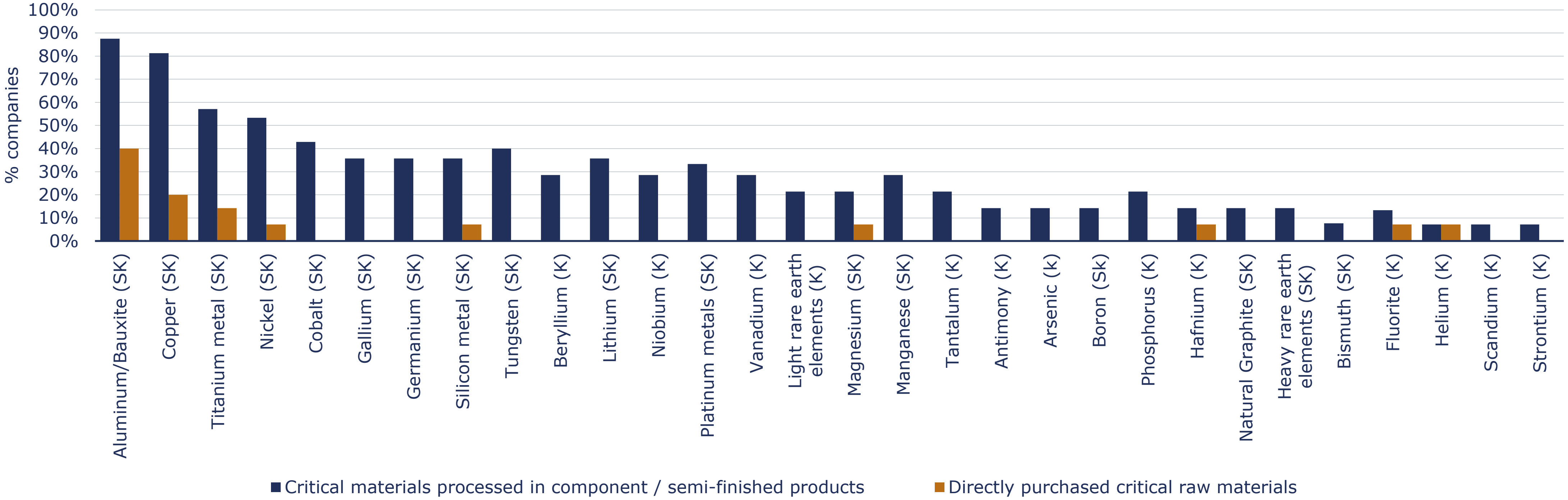
Source: NLDTIB Berenschot, 2024

Dutch Defence companies directly purchase critical raw materials to a very limited extent

During the interviews questions included the use of critical raw materials and the extent to which they are purchased directly.

- Aluminium/bauxite, copper, titanium metal and nickel are most commonly used. Although there are differences in emphasis, the picture is consistent with the results of the NLDTIB questionnaire.
- Only aluminium/bauxite is relatively much directly purchased (often in processed form), the other critical raw materials almost not.

Use of critical materials processed in components and purchase critical raw materials within NLDTIB

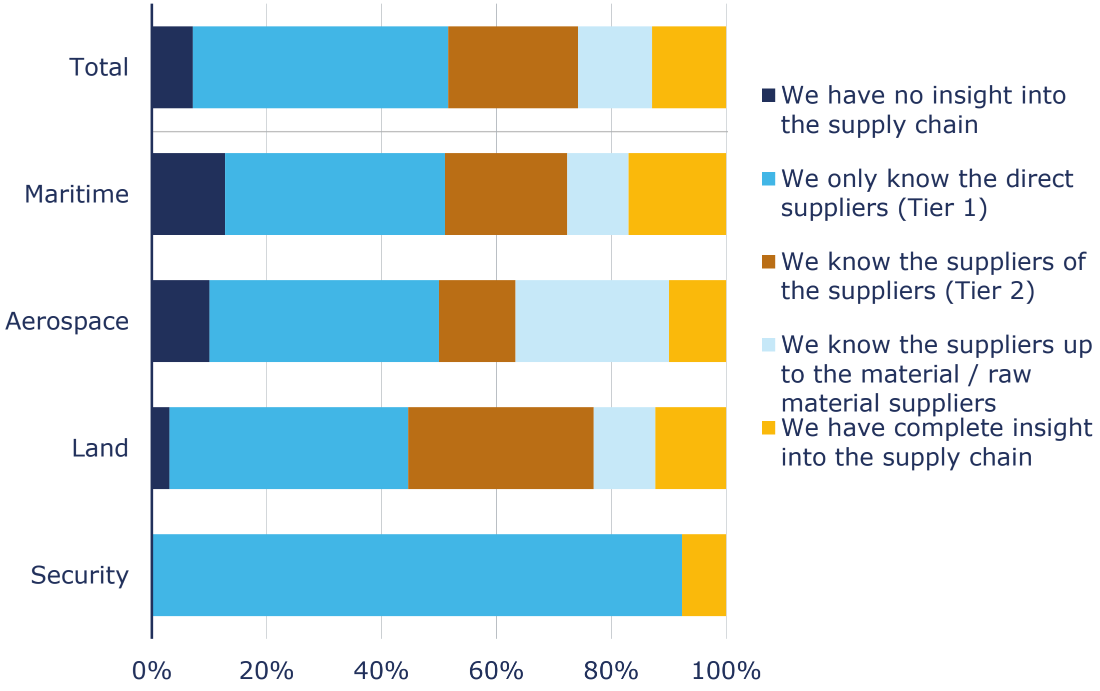


Source: Berenschot, 2024

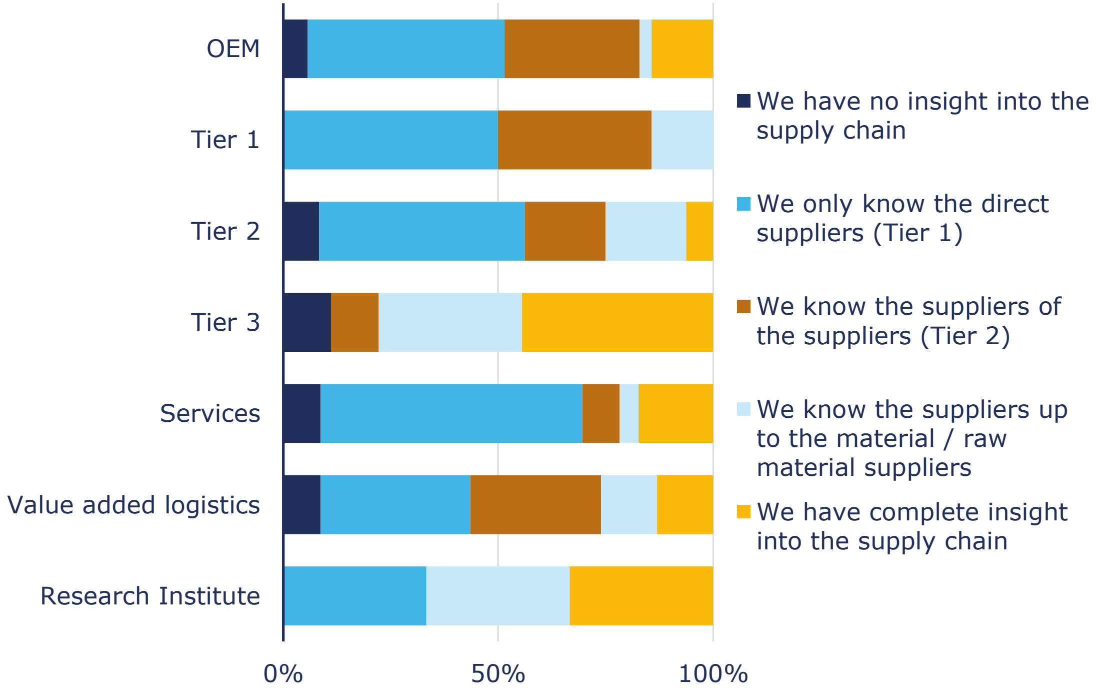
Dutch Defence companies have limited insight into the value chain

- Companies indicate limited visibility into the value chain.
- In the aerospace domain, companies are relatively more likely to know suppliers up to material/raw material suppliers. Interviews reveal that there are a limited number of players within this domain.
- The further upstream companies are in the value chain, the better visibility there is. In particular, OEMs and tier 1 have relatively limited visibility into the value chain.

Insight into the value chain of suppliers NLDTIB (production locations, material use)



Insight into the value chain of suppliers NLDTIB (production locations, material use)

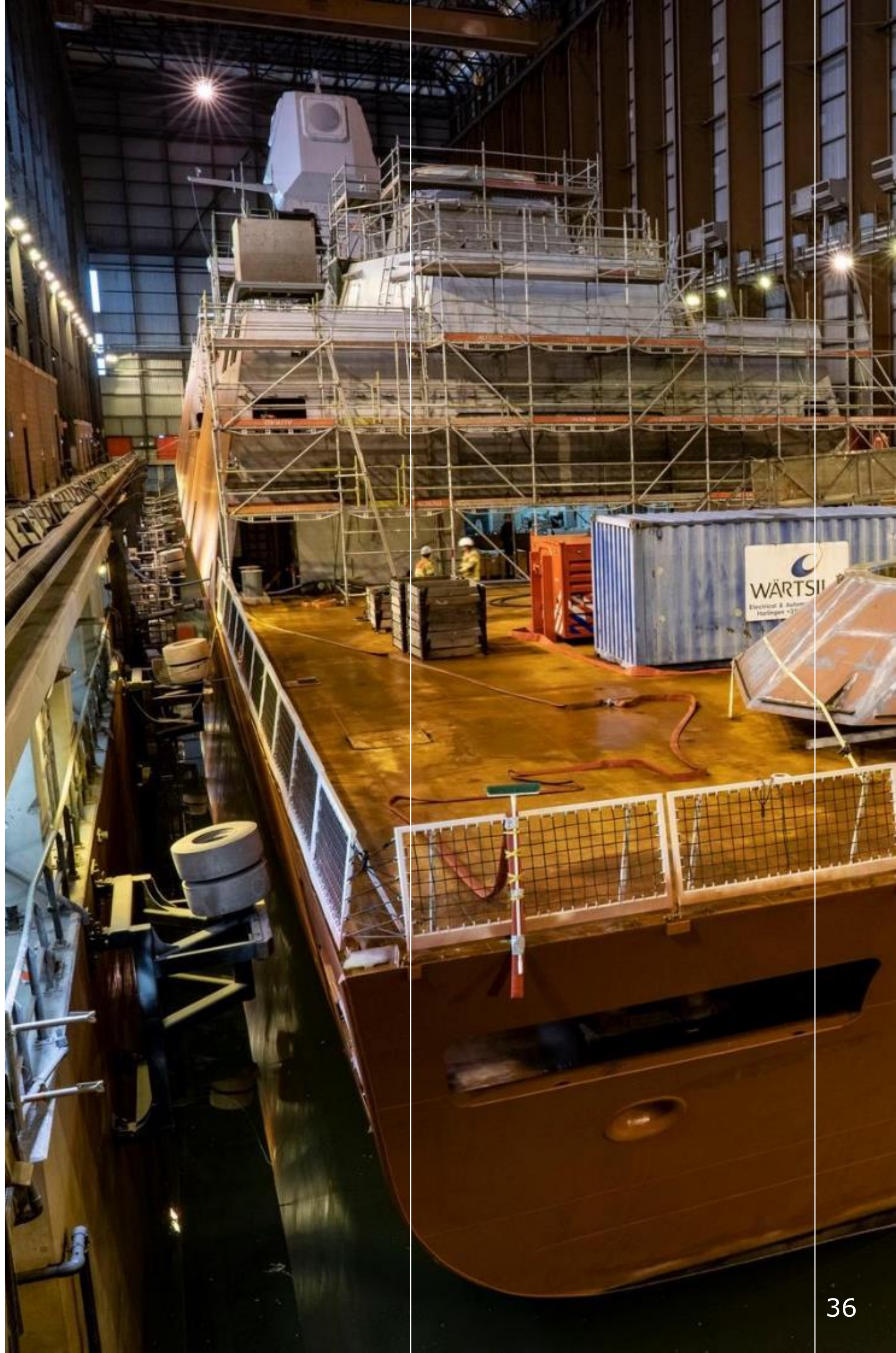


Source: NLDTIB Berenschot, 2024

OEMs and tier 1 mainly have limited insight into the value chain

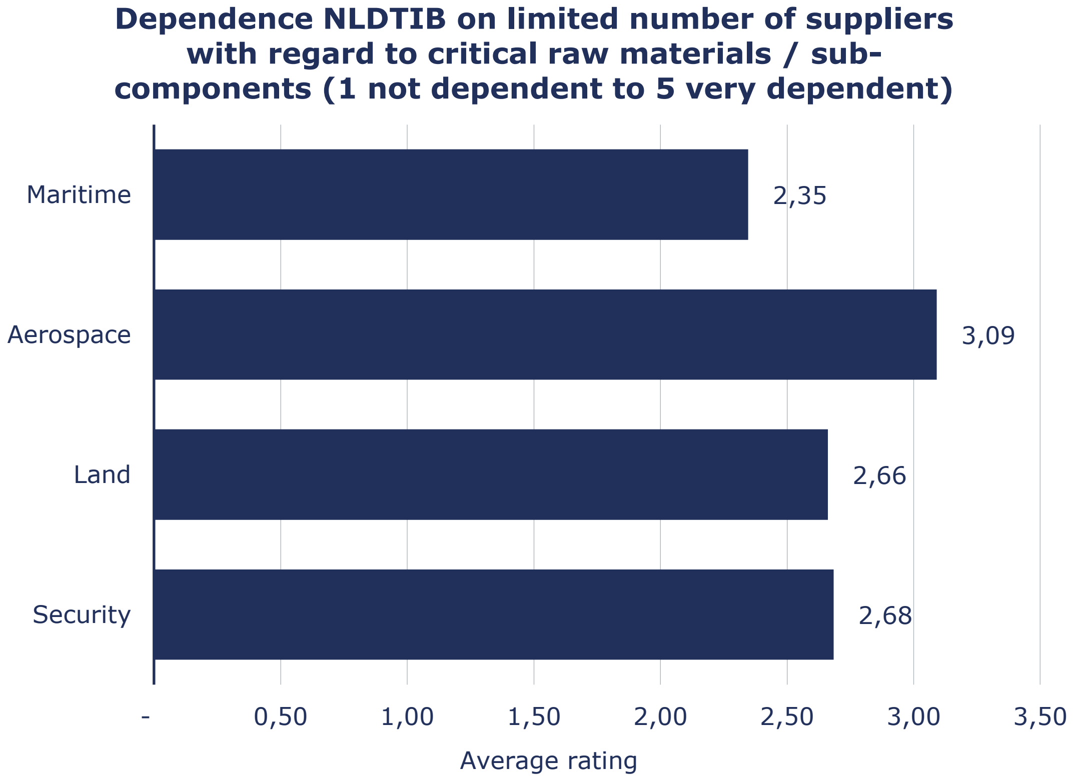
Companies have limited insight into where suppliers source (sub)components and the critical raw materials incorporated in them.

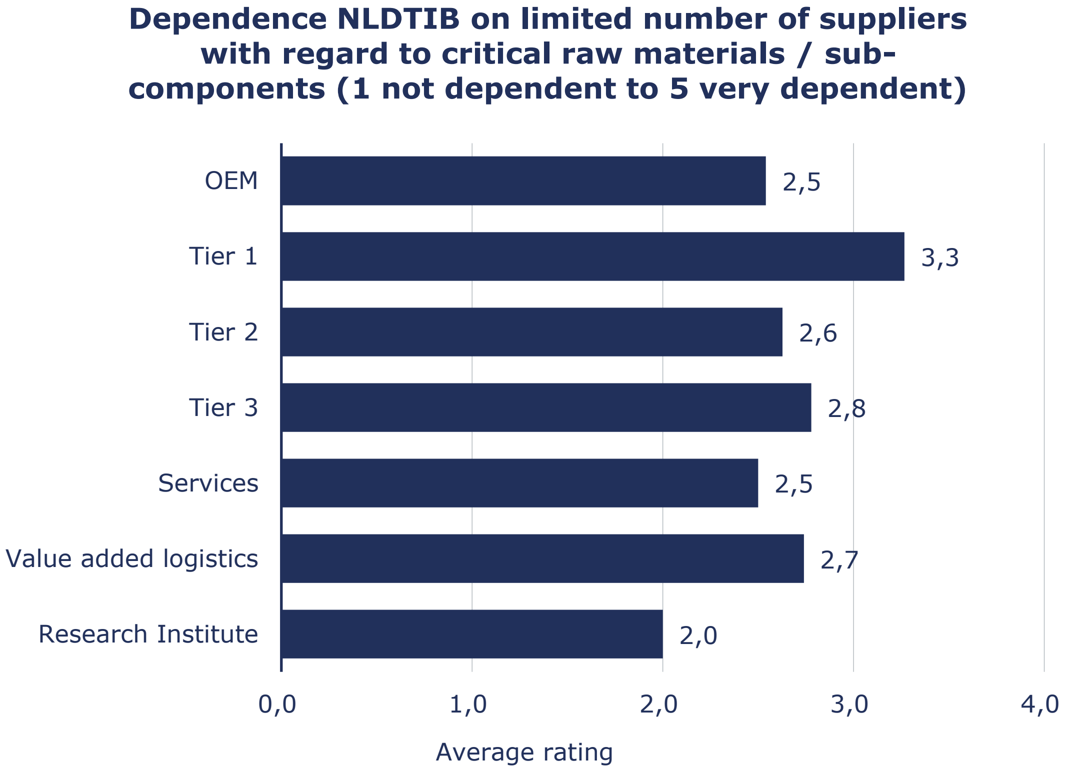
- In particular Dutch OEMs in the maritime and land domain often only know their tier 1 suppliers. Where tier 2 and 3 suppliers source and produce is less often known.
- Often, knowledge regarding the processing of critical raw materials and associated dynamics resides with tier 2 or tier 3 companies.
- The need to map value chains is felt to a limited extent. However, companies do indicate that they are increasingly working on this.
- Companies indicate that cost price is a much more important factor than shortages of certain materials, components and/or raw materials. Due to just-in-time production, materials are kept in stock to a limited extent.
- The maritime domain and its suppliers are largely present in the Netherlands. Production partly takes place abroad, although engineering and finishing take place in the Netherlands. Companies are mainly ‘first tier oriented’ and have very limited focus on value chains.
- The use of licensed production in the aerospace domain in particular, where US OEMs prescribe specifications and suppliers, cause a lack of necessity to explore the value chain in more detail as freedom of supplier choice is limited.
- Value chains within the land domain are particularly focused on Western Europe and mainly on Germany. With regard to critical raw materials, the majority of critical raw materials (via traders, intermediate suppliers or semi-finished products) appear to come from China in processed form, as far as is known.



Aerospace and tier 1 are more dependent on a limited numbers of suppliers

- Companies were asked to what extent there is dependence on a limited number of suppliers with regard to critical raw materials and/or the (sub)components that incorporate these critical raw materials.
- Companies in the aerospace domain indicated the most dependence, maritime companies the least.
- Tier 1 in particular indicates that it is more dependent on a limited number of suppliers.





Source: NLDTIB Berenschot, 2024

The aerospace domain and high-tech are mainly dependent on limited numbers of suppliers

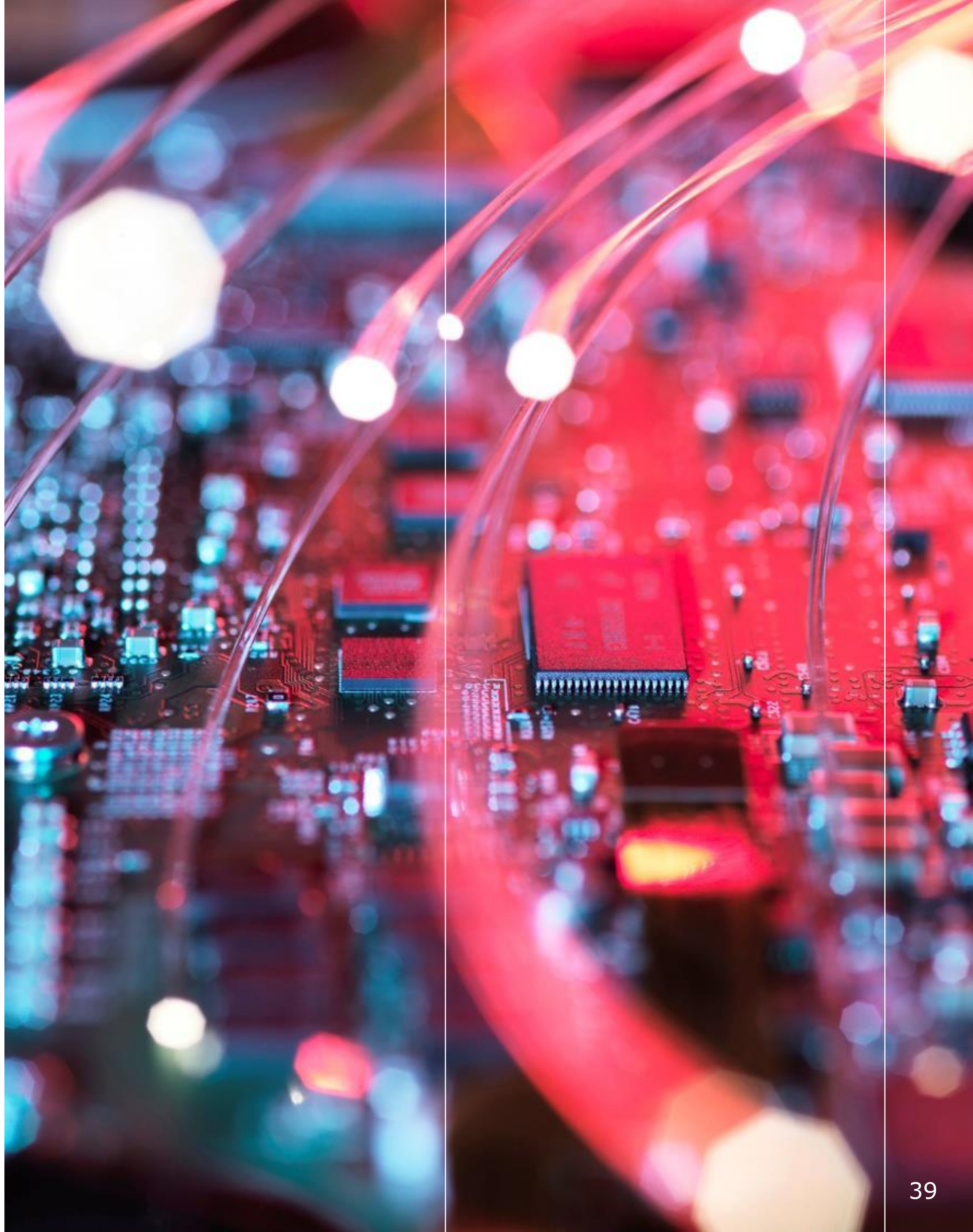
- A limited number of suppliers brings challenges. For instance, delivery times can exceed one or two years, and there are examples where prices have been (tripled) within the ‘foreseeable future’.
- High-tech companies and companies in the aerospace domain in particular indicate their dependence on a limited number of suppliers of critical raw materials or (sub)components, the interviews revealed.
- In aerospace, there is a lot of licensed production where US OEMs determine from which suppliers the components should be sourced upstream. Dutch companies in those chains are therefore stuck with specific suppliers and have limited freedom of choice.
- Aerospace also has a different kind of supply chain risk. Companies have very specific requirements, but procurement volume is low. For instance, chips are needed to withstand cosmic radiation. Prices are at such high levels that ‘off-the-shelf’ chips are sourced. This negatively affects the life expectancy of a satellite.
- In the land domain, with regard to the supply chain of tanks, the problem of low production numbers combined with high requirements also plays a role.
- German company Azur Space Solar Power is the only manufacturer of A-quality satellite solar panels. Because of doubled prices and 2+ yearlong delivery times, companies are turning to B-grade solar cells. These are sufficient for various purposes, but not for e.g. ESA missions.
- In the maritime domain, there is generally a lot of freedom of choice, due to the high ‘dual-use’ nature of vessels. Companies report having multiple suppliers to choose from. With regard to critical raw materials, other uses of raw materials are also possible, although at the expense of product performance.
- Within the land domain, there are also companies with such specific applications that there is dependence on a limited number of suppliers. For the procurement of advanced chips for use in night vision equipment and radar technology, among others, there is high dependence on five suppliers located in France, Israel, the United States and China. The same applies to sourcing thermal imaging sensors. Currently, only single-source sourcing from France is feasible and acceptable due to geopolitical tensions.
- Supply qualifications for semiconductors take months or years. It is not easy to acquire new suppliers.
- Companies indicate that it is not just about dependence on materials incorporating critical raw materials, but also critical materials without critical raw materials. For instance, there is dependence on a very limited number or even a few suppliers for certain materials, whose suppliers are also located in third countries. For example, the production of bullet and fragment-proof materials with super fibres, where only Teijin Aramid, Dupont and Dyneema are global suppliers.

Semiconductors essential for the European and Dutch Defence industry

Due to the frequent use of (high) technology applications in all domains, the availability of semiconductors is essential for the Dutch defence industry. For the manufacturing of semiconductors, the availability of critical raw materials is essential.

- The semiconductor industry is at the forefront of the raw materials discussion: the subject is regarded as relevant, there is more awareness and there more actively being worked on. Particularly with regard to securing supply chain risks and reducing risk with regard to China. Reducing the use of critical materials/raw materials is also an issue. Nevertheless, technology performance improvement is more important.
- Several critical raw materials are used to manufacture semiconductors: cobalt, palladium, tantalum, germanium, vanadium, tungsten and gallium.
- Taiwan produces about 90% of the world's most advanced semiconductors, most of which come from manufacturer TSMC. As a result of the US Chips Act and the European chip regulation, aimed at reducing dependencies, TSMC is forced to produce closer to its markets. For instance, TSMC plants are now being built in Dresden, Arizona and Japan. However, the majority of TSMC's operations remain in Taiwan. On the other hand, developments in semiconductor are going particularly rapid, partly because China is investing in it.
- Meanwhile, several semiconductors used for defence applications come from South Korea, a relatively stable and NATO-friendly country. South Korea has built up a high-quality semiconductor industry and semiconductor products are the country's largest export product.

Source: NOS, 2024. Chips zijn Taiwans levensverzekering tegen China, maar hoelang nog?



Berenschot

6. Country analysis of the supply chains

Dependencies, risks and measures with regard to the use of critical raw materials within the Dutch DIS areas

Public

Supply chain and country analysis: NLDTIB is very internationally connected

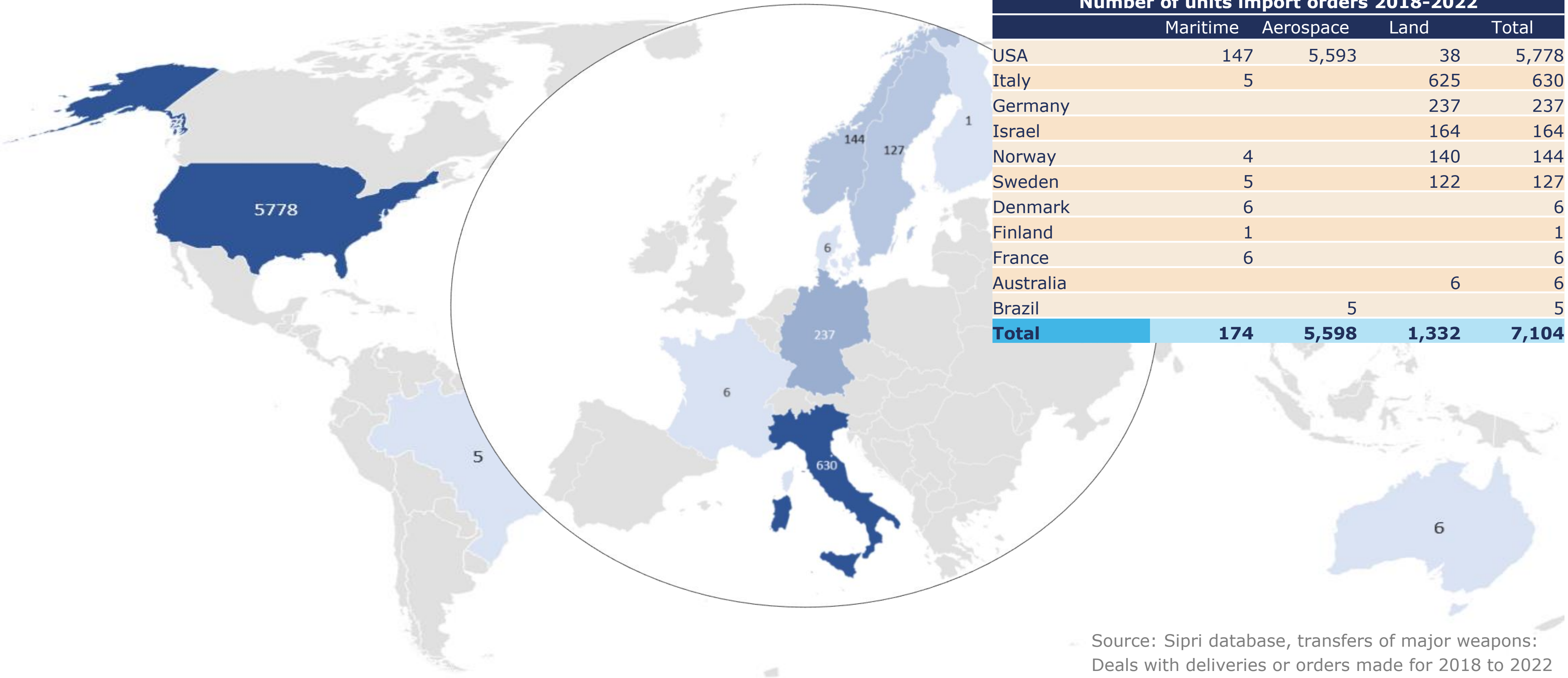
- The risk analysis of the supply chain by country was carried out on the basis of equipment used by the Ministry of Defence, the sales and procurement market of the Dutch defence industry, trade flows between countries regarding weapon systems and military goods, 11 key product groups for the defence industry and the ownership relationships of companies active in the Dutch defence industry.

- The analysis was carried out according to the following dimensions:
  - Country of origin of equipment Dutch Ministry of Defence.
  - Country of origin based on import of weapon systems.
  - Sales market of the Dutch Defence industry.
  - Purchasing market of the Dutch Defence industry.
  - Production facilities of the Dutch Defence industry.
  - Destination country of export, based on licenses of military products.
  - Analysis of world trade data for 11 important product groups for the Defence industry.
  - Analysis of Ultimate Beneficial Owners (UBOs) of the Dutch Defence industry.

- Maritime platforms of the equipment at the Ministry of Defence primarily originate from the Netherlands (89% of the defense equipment type and 45% of vessels).
- The equipment in the Dutch air force primarily originates from the United States (72% of the aircraft).
- The origin of equipment of the Dutch land forces is much more spread to different countries, especially Europe.
- The armament of the Dutch Ministry of Defence comes from Europe and the USA. USA supplies the most weapon systems to the Netherlands (81%).
- NLDTIB's sales are global. The NLDTIB is strongly export-oriented. A large part of defence exports goes to USA and Europe.
- NLDTIB production is primarily located in the Netherlands.
- NLDTIB's procurement value chain is primarily in Europe, other Asia and the USA. Electronics and components are mainly from China and Asia.
- The NLDTIB has strong international connections. 28% of NLDTIB companies have a foreign shareholder ‘ultimate beneficial owner’ (UBO).

The Netherlands imports the majority of weapon systems from the United States (81%)

- Shown are the import flows of orders for weapon systems to the Netherlands over the period from 2018 to 2022. Shown are the total number of pieces of orders between 2018 and 2022.



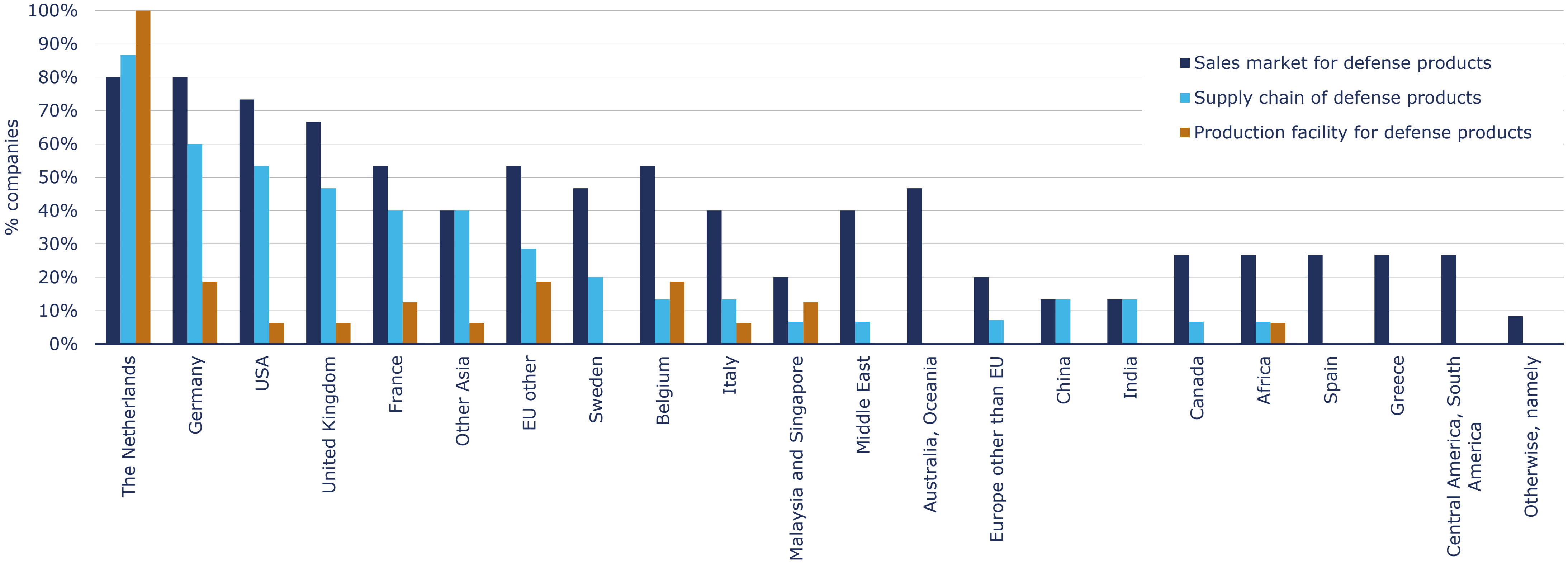
Number of units import orders 2018-2022				
	Maritime	Aerospace	Land	Total
USA	147	5,593	38	5,778
Italy	5		625	630
Germany			237	237
Israel			164	164
Norway	4		140	144
Sweden	5		122	127
Denmark	6			6
Finland	1			1
France	6			6
Australia			6	6
Brazil		5		5
Total	**174**	**5,598**	**1,332**	**7,104**

Source: Sipri database, transfers of major weapons: Deals with deliveries or orders made for 2018 to 2022

NLDTIB: global sales, production in the Netherlands, purchasing primarily in Europe, the United States and Asia

- The sales market, purchasing value chain and production facilities of the Dutch Defence industry are analysed.
- The additional interviews and in-depth questionnaires revealed that production primarily takes place in the Netherlands, and to a limited extent in Europe and North America.
- Procurement value chains are mainly located in the Netherlands and Europe. A limited part of the purchase value chains are located in China and India.
- The sales market is strongly international.

Sales market, purchasing value chain and production facilities NLDTIB

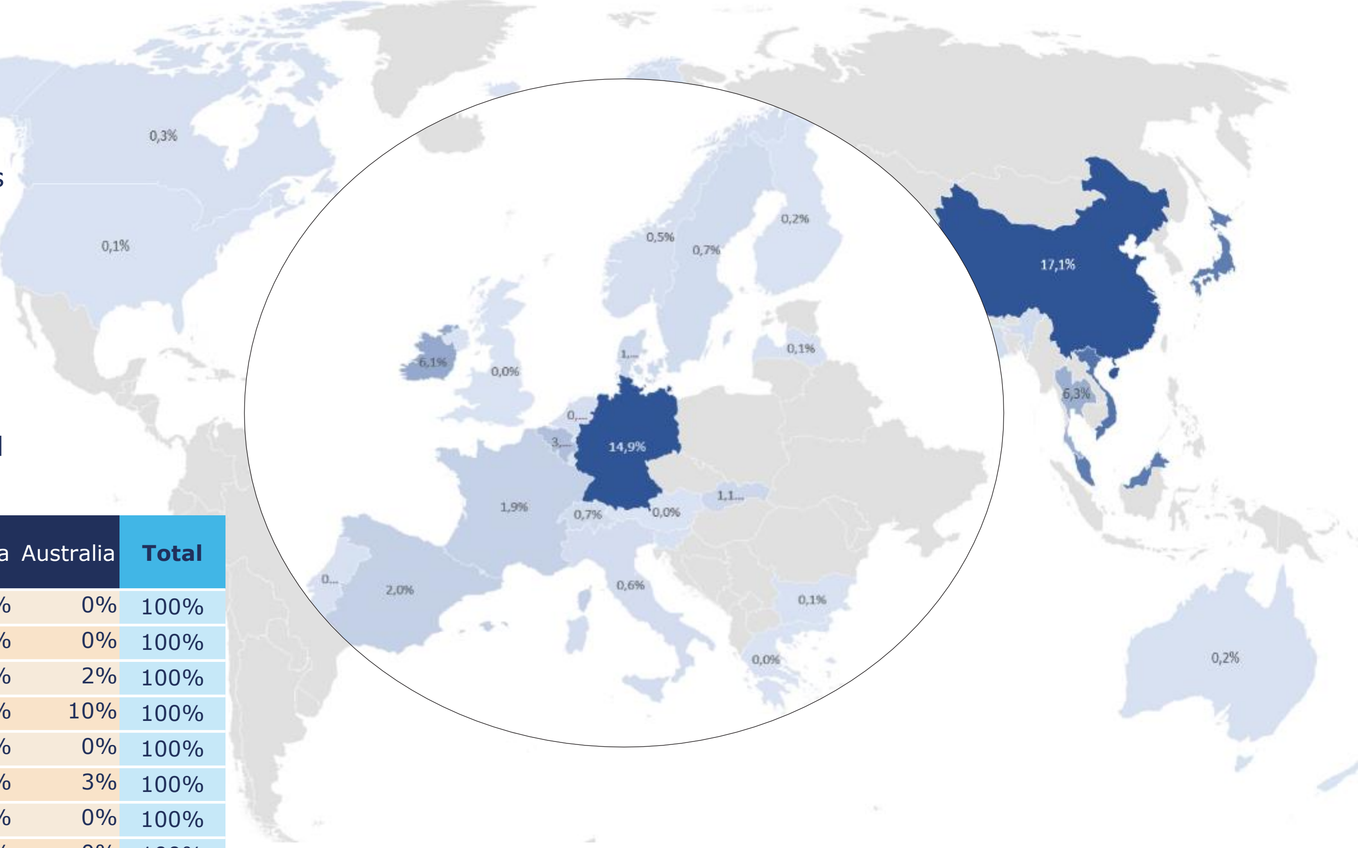


Source: Berenschot, 2024

Dependence on eleven product groups: electronics and parts primarily come from China and Asia

- As the Dutch defence industry does not buy raw materials but (sub)components, the risks were mapped for 11 key (dual-use) product groups. The analysis gives a picture of the concentration of some key industries for defence.
- Based on world trade data, the production value of 11 product groups was estimated. Shown is the share by country of the net amount between exports and imports.
- Explosives, ammunition and tanks come mainly from Europe, Asia and North America.
- Electronics and components originate mainly from China and Asia.
- Account needs to be taken of production that stays within the country and impurities in data. Many trade flows pass through Europe.

HS code	Value of production Defence specific products (source comtrade 2022)	Europe	Asia	China	North America	Africa	Australia	Total
360200	Explosives	23%	28%	0%	16%	33%	0%	100%
930690	Ammunition	54%	24%	0%	6%	16%	0%	100%
871000	Tanks and other armored vehicles	70%	2%	0%	10%	16%	2%	100%
880623	Unmanned aircraft	32%	0%	32%	14%	12%	10%	100%
880212	Helicopters	50%	24%	0%	13%	13%	0%	100%
852990	Reception and transmission apparatus	67%	29%	0%	0%	0%	3%	100%
382499	Chemical products	63%	36%	2%	0%	0%	0%	100%
853400	Circuits printed	8%	41%	51%	0%	0%	0%	100%
854233	Electronic integrated circuit amplifiers	1%	34%	65%	0%	0%	0%	100%
852589	Television cameras	9%	91%	0%	0%	0%	0%	100%
848340	Gears and gearing	65%	33%	0%	0%	0%	1%	100%
	Total	35%	47%	17%	0%	1%	0%	100%



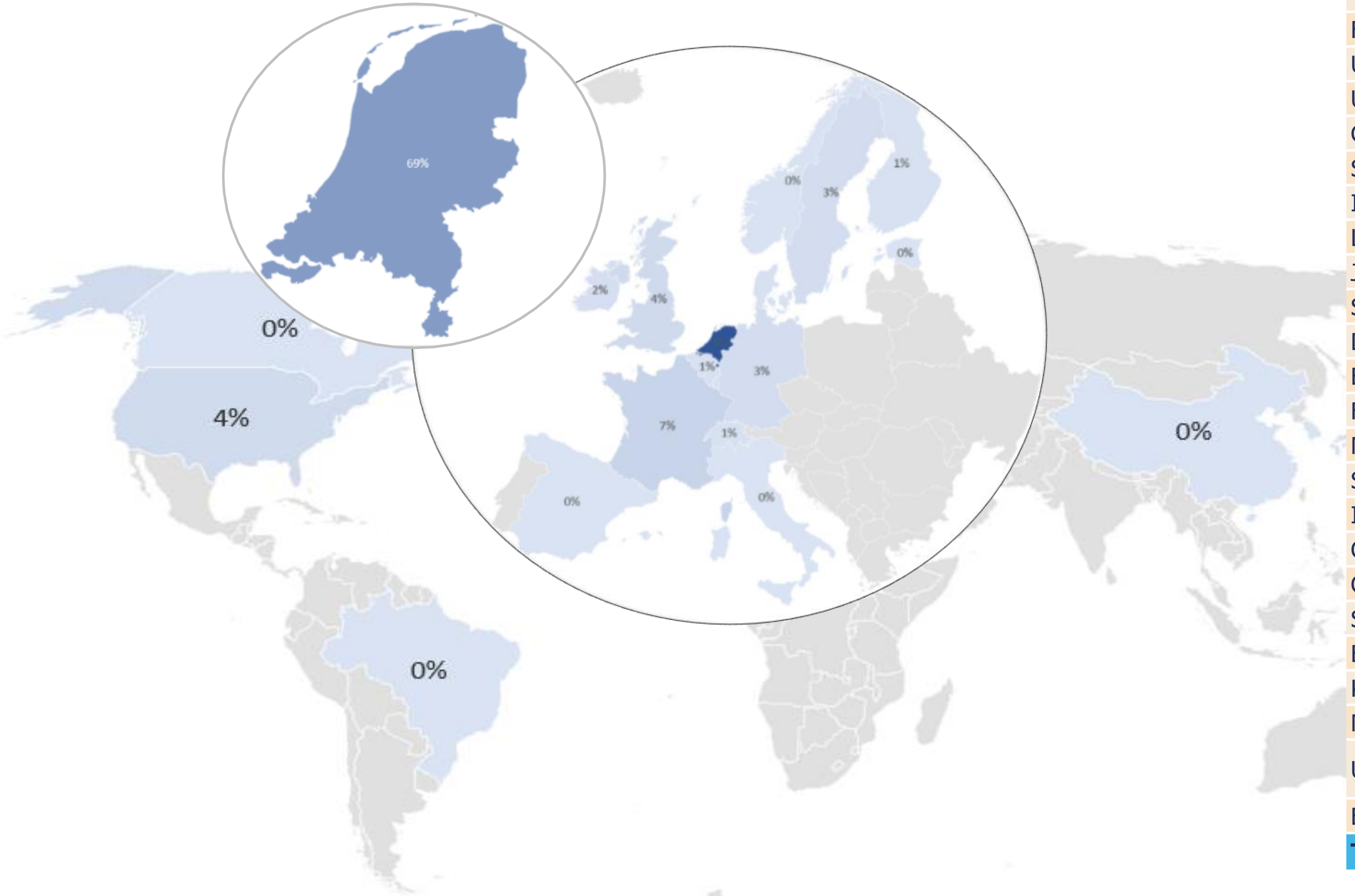
Source: TNO / Comtrade 2022
NB. The figures concern total world trade at product group level, not directly specified for the Netherlands.

Explanation of UBO methodology

- The survey of Ultimate Beneficial Owner (UBOs) was made on the basis of the approximately 1,000 companies in the Dutch defence and security industry (NLDTIB). As part of this research, the UBOs were mapped to a first level, i.e., an inventory was made of the domicile countries of the shareholding entities as listed in the Chamber of Commerce register.
- The column 'Country of establishment of legal owner' indicates the country of establishment of the shareholding entities. This is the country of residence of the legal owner of the Dutch entity. The legal owner may be an entity that includes other shareholders with other nationalities, as in the case of listed companies. The ultimate shareholders are not shown in this overview. A company part of or involved in private equity is often financed indirectly through private individuals, pension funds or other shareholders. Thus, it is also not disclosed which persons are major shareholders of a listed company. This shareholdership is not registered by the Chamber of Commerce and can change by the day.
- To know the origin of owners/persons of the shareholding entities, effectively the ultimate decision-makers, further research is needed. The main question should be: who are the ultimate shareholders of corporate-level entities and what is their share? This could be conducted in cooperation with Bureau of Review and Investment (met Bureau Toetsing Investeringen).

28% of NLDTIB companies have a foreign shareholder 'ultimately beneficial owner' (UBO)

- In total, there are about 1,000 companies in the Netherlands operating in the defence and security industry. These companies employ 209,000 workers in the Netherlands. Of these companies, 28% have a foreign owner, or who has control or an interest.



Legal owner's country of residence	FTE NL 2022	%	# businesses	%
The Netherlands	145,116	69%	782	72%
France	15,107	7%	29	3%
United Kingdom	9,335	4%	30	3%
USA	8,596	4%	47	4%
Germany	6,027	3%	57	5%
Sweden	6,318	3%	25	2%
Ireland	3,633	2%	3	0%
Luxembourg	2,532	1%	8	1%
Japan	2,408	1%	10	1%
Switzerland	2,178	1%	17	2%
Denmark	1,829	1%	10	1%
Belgium	1,870	1%	26	2%
Finland	1,578	1%	6	1%
Norway	673	0%	5	0%
Singapore	759	0%	3	0%
Italy	508	0%	7	1%
Canada	432	0%	6	1%
China	282	0%	3	0%
Spain	131	0%	1	0%
Brazil	95	0%	1	0%
Korea	64	0%	1	0%
New Zealand	24	0%	1	0%
United Arab Emirates	15	0%	1	0%
Estonia	4	0%	1	0%
Total	**209,513**	**100%**	**1,080**	**100%**

Source: Company.info, Chamber of Commerce (2024)

Berenschot

7. Risk analysis of the supply chains

Dependencies, risks and measures with regard to the use of critical raw materials within the Dutch DIS areas

Risk analysis methodology for critical raw materials

- The risk analysis is an assessment of critical raw material supply security bottlenecks (including number of suppliers, substitutes, volume of reserves, shortages, innovation and recycling opportunities) and geopolitical bottlenecks (including country of origin of raw materials, country barriers and country stability).
- When risks are present, there is an impact on defence in the Netherlands. This can put pressure on the Ministry of Defence's procurement plans, as well as defence industry supply chains.
- The risk analysis identifies the risk and impact with regard to critical raw materials.
- For each critical raw material, the supply chain risk and the frequency of use in the Dutch defence industry were studied.
- Although per critical raw material the supply chain risk is fixed, the degree of impact varies considerably between defence domains. For this reason, there are specific vulnerabilities for each defence domain analysed.
- For each overview, the average supply chain risk and average usage is marked with a vertical and horizontal line. Thus, it is visible which critical commodities have a higher-than-average risk.

- The supply risk index as issued per raw material by the European Commission in 2023 on the basis of the EC criticality methodology (Study on criticism raw materials for the EU, 2023), was used for the supply risks per raw material. This is an internationally widely used and accepted index. In the EC criticality methodology, the following risks have been taken into account:

Supply chain risk
  - Global Supply concentration and EU Sourcing concentration (Herfindahl-Hirschman-Index)
  - Country Governance (WGI)
  - Import reliance
  - Trade restrictions
  - Supply chain/bottlenecks
  - End of Life Recycling Input rate (EOL -RIR)

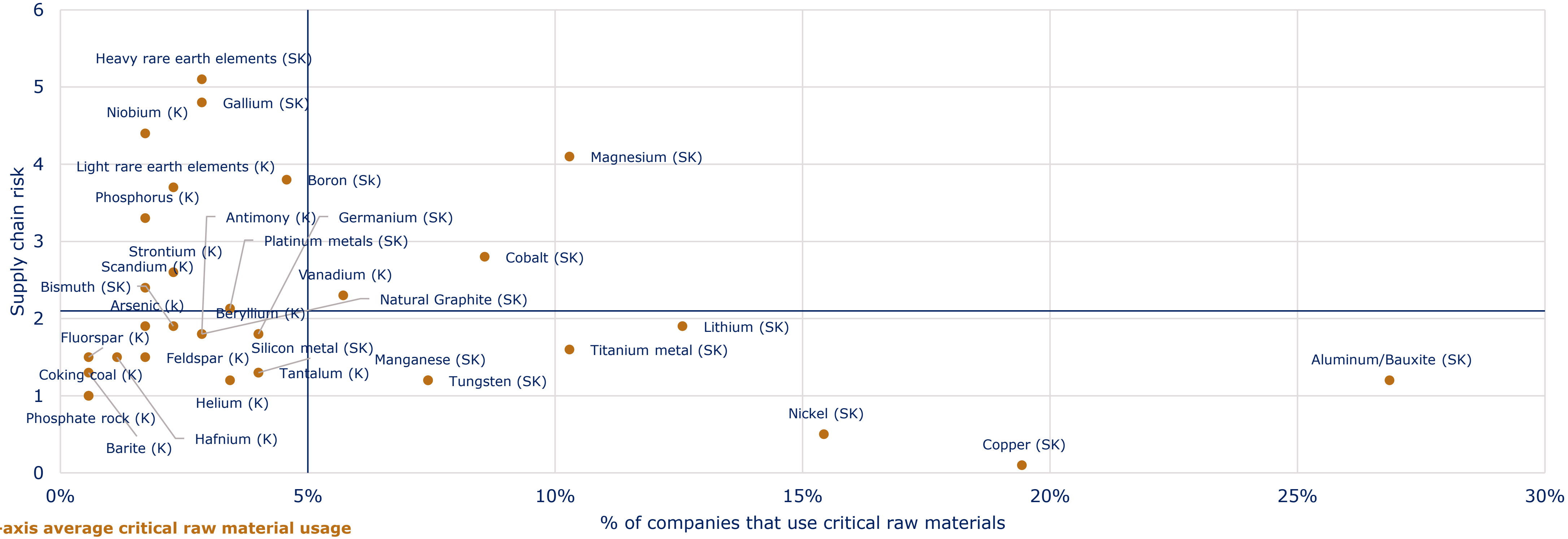
SUPPLY RISK ANALYSIS CHAINS

Limited risk with commonly used critical raw materials

- The risk and impact for each critical raw material has been mapped. The impact refers to the percentage of companies using the critical raw material. The risk was determined based on the supply chain risk of the relevant critical raw material, as set by the European Commission (2023).
- Aluminium, copper and nickel are relatively widely used but have relatively low supply chain risks. The risk for magnesium is high, combined with high use.
- Cobalt, lithium and titanium are also used relatively frequently, with average supply chain risks.

Supply chain risk is based on global supply EU, recycling, available substitutes

Risk and impact per critical raw material, whole Dutch Defence industry



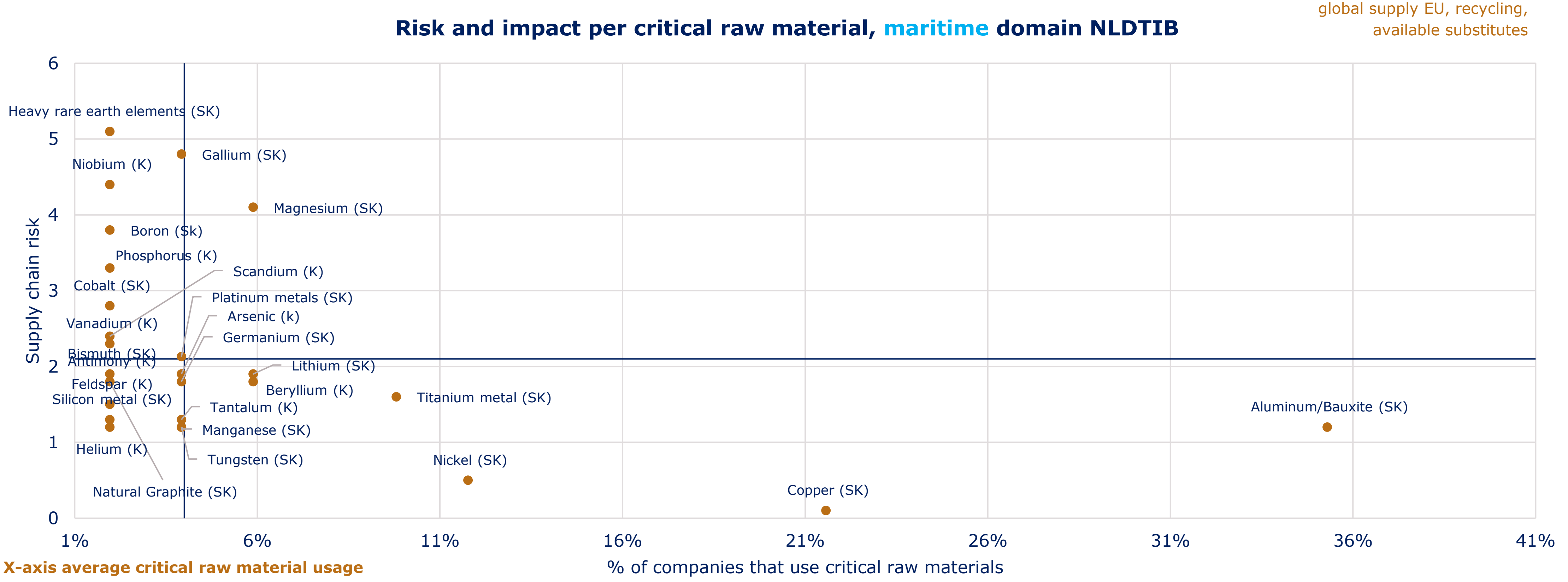
X-axis average critical raw material usage
Y-axis average supply chain risk

Source: NLDTIB Berenschot, 2024

Aluminium/bauxite in particular is widely used in the maritime domain

- A limited number of critical raw materials are used within the maritime domain.
- Only a relatively large amount of aluminium/bauxite is used.

Supply chain risk is based on global supply EU, recycling, available substitutes



X-axis average critical raw material usage
Y-axis average supply chain risk

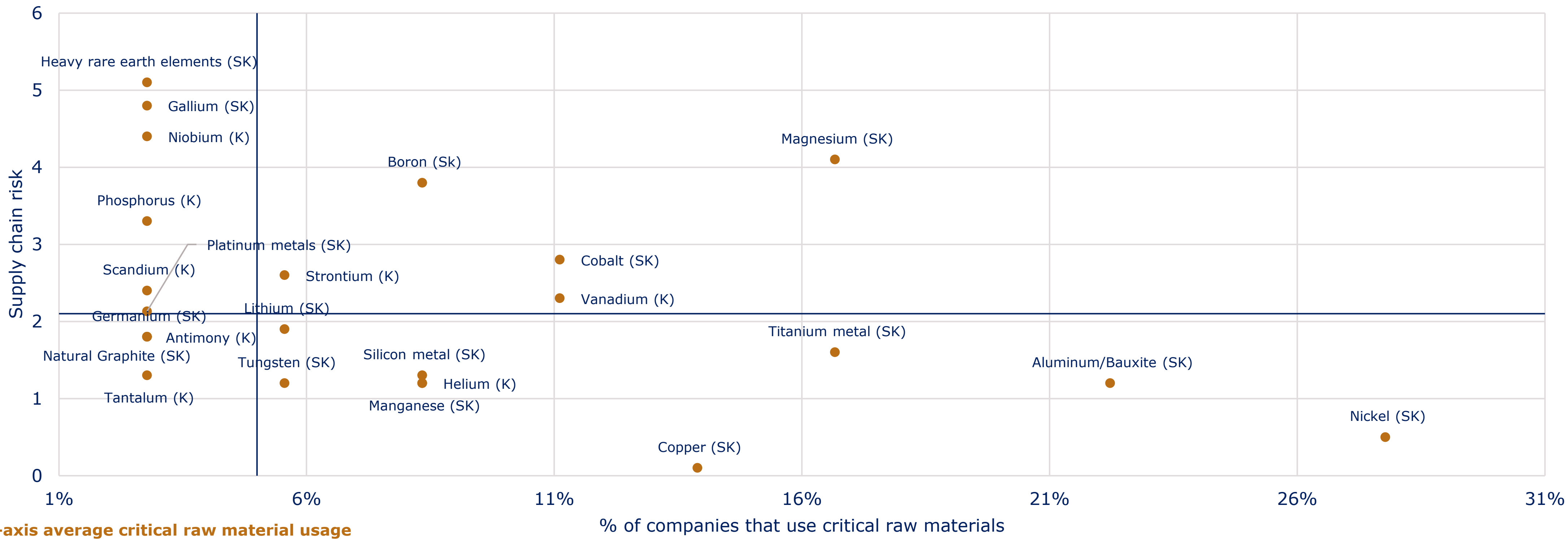
Source: NLDTIB Berenschot, 2024

In the aerospace domain, there is more use of critical raw materials with a high risk

- Relatively more critical raw materials are used in the aerospace domain.
- In particular, greater use of boron, magnesium, cobalt vanadium and nickel can be seen.

Supply chain risk is based on global supply EU, recycling, available substitutes

Risk and impact per critical raw material, aerospace domain NLDTIB



X-axis average critical raw material usage
Y-axis average supply chain risk

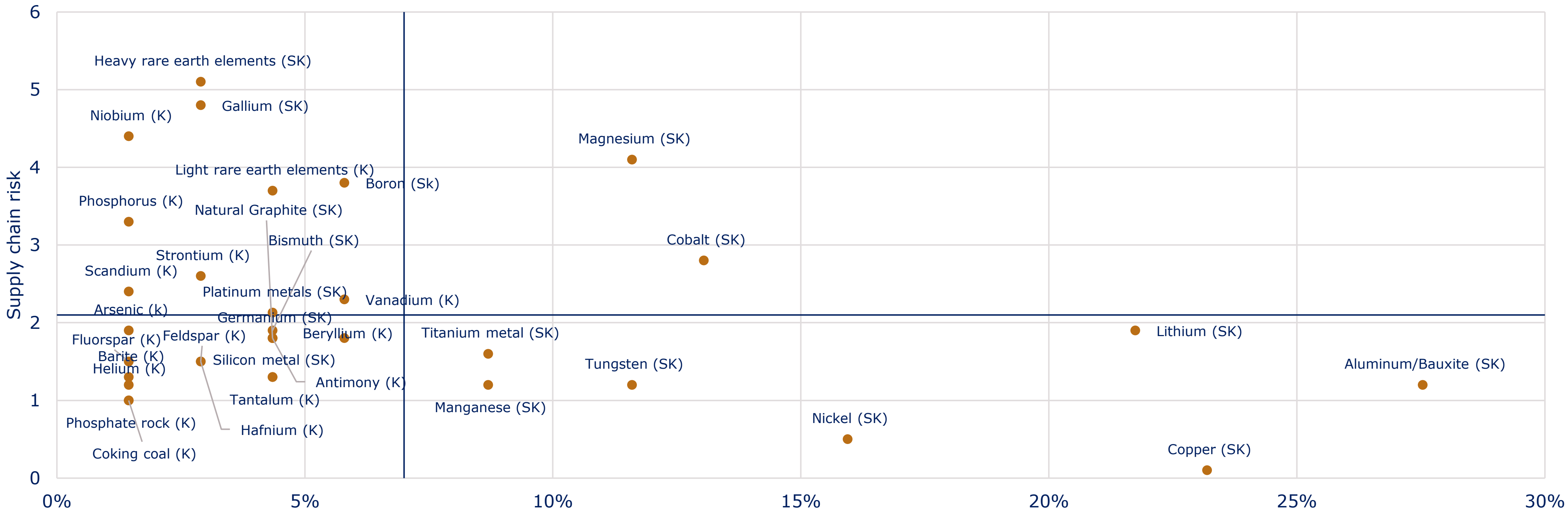
Source: NLDTIB Berenschot, 2024

Higher use of copper and lithium in land domain

- Within the land domain there is extensive use of critical raw materials with a high risk, such as cobalt, lithium and magnesium.

Supply chain risk is based on global supply EU, recycling, available substitutes

Risk and impact per critical resource, land domain NLDTIB



X-axis average critical raw material usage
Y-axis average supply chain risk

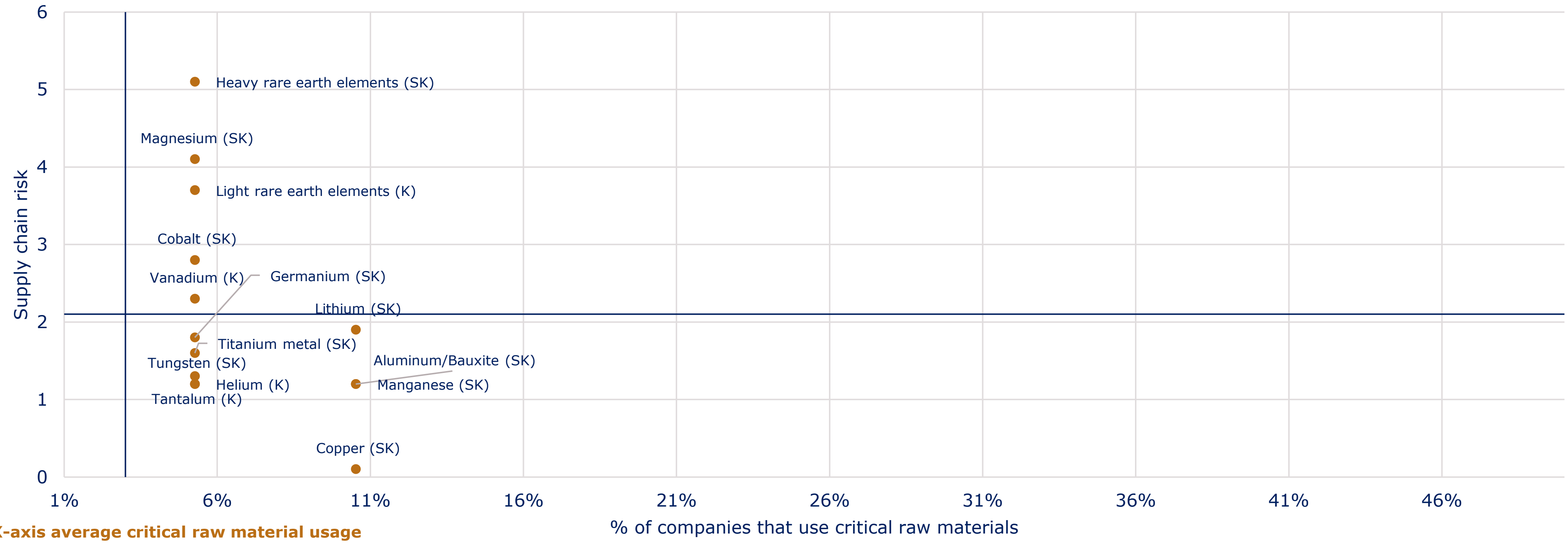
Source: NLDTIB Berenschot, 2024

Limited use of critical raw materials in the security domain

- Limited critical raw materials are used within the security domain.

Supply chain risk is based on global supply EU, recycling, available substitutes

Risk and impact per critical raw material, security domain NLDTIB



X-axis average critical raw material usage
Y-axis average supply chain risk

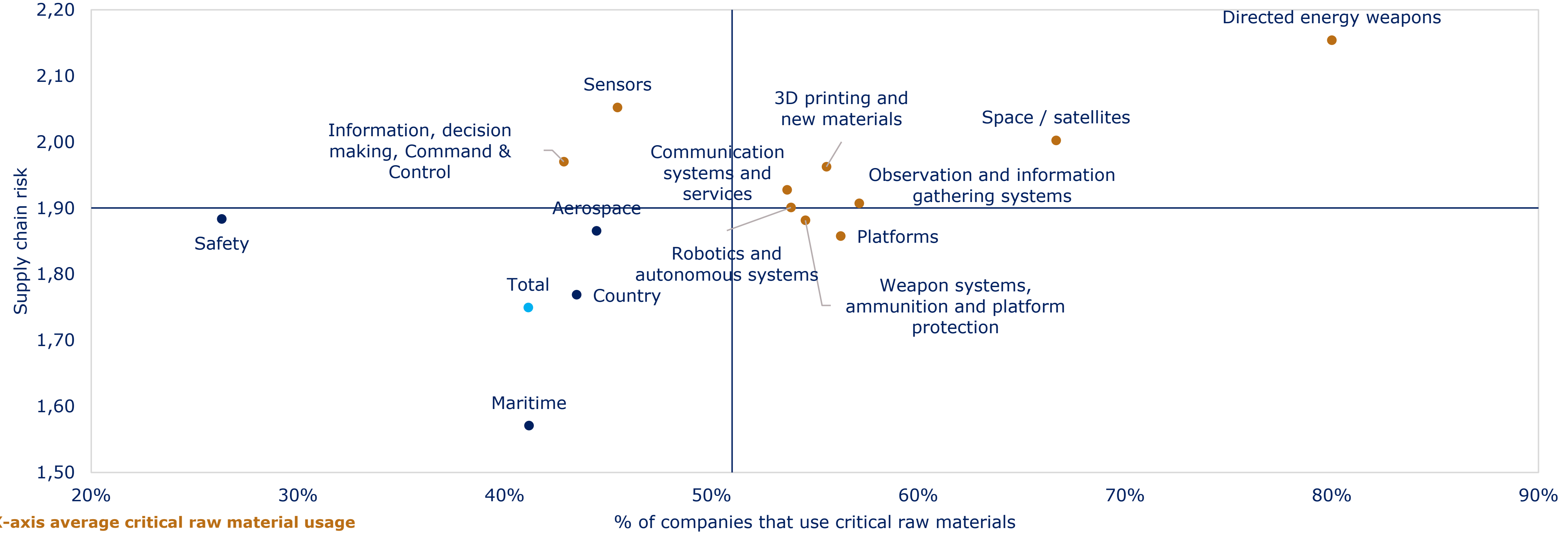
Source: NLDTIB Berenschot, 2024

Especially CRM risks within the DIS areas and the aerospace domain

- Companies in specific DIS areas have a higher risk than the average for land, air, maritime and security domains. Business Services and trading companies are included within the domains. These are less dependent on critical raw materials.
- High-tech domains and DIS areas have higher risks.
- Direct energy weapons have high risks and use many critical raw materials. However, only 3% of the NLDTIB companies are active in this DIS area.

Supply chain risk is based on global supply EU, recycling, available substitutes

Risk and impact per critical commodity, domains and DIS areas NLDTIB



X-axis average critical raw material usage
Y-axis average supply chain risk

Source: NLDTIB Berenschot, 2024

Country risk analysis methodology

- For the Dutch defence industry, it was examined in which countries mining and processing of the used critical raw materials takes place. Due to limited insight into the chains, complexity of the chains and processing into (sub)components, it is not known where the raw materials of the Dutch defence industry actually come from.
- The overviews show the percentage of critical raw materials as used in the Dutch defence industry (the frequency) per country and the country risk per country.
- The risk analysis maps the risk and impact with regard to critical raw materials per country.
- Companies were able to indicate multiple critical raw materials, so the total adds up to more than 100%.

- A weighted average of the following measures was used for country risk:
  - World Bank Worldwide Governance Indicators (WGI) index.
  - OECD country risk classification measures a country's credit risk and the likelihood that a country will pay off its foreign debts.
  - Atradius STAR scale. STAR stands for Sovereign Transfer and Arbitrary Risk and represents a rating system for assessing country risk by credit insurer Atradius.
  - Fragile state index. The ranking of the index is based on twelve indicators of states' vulnerability, grouped by category: Cohesion, Economic, Political, Social.

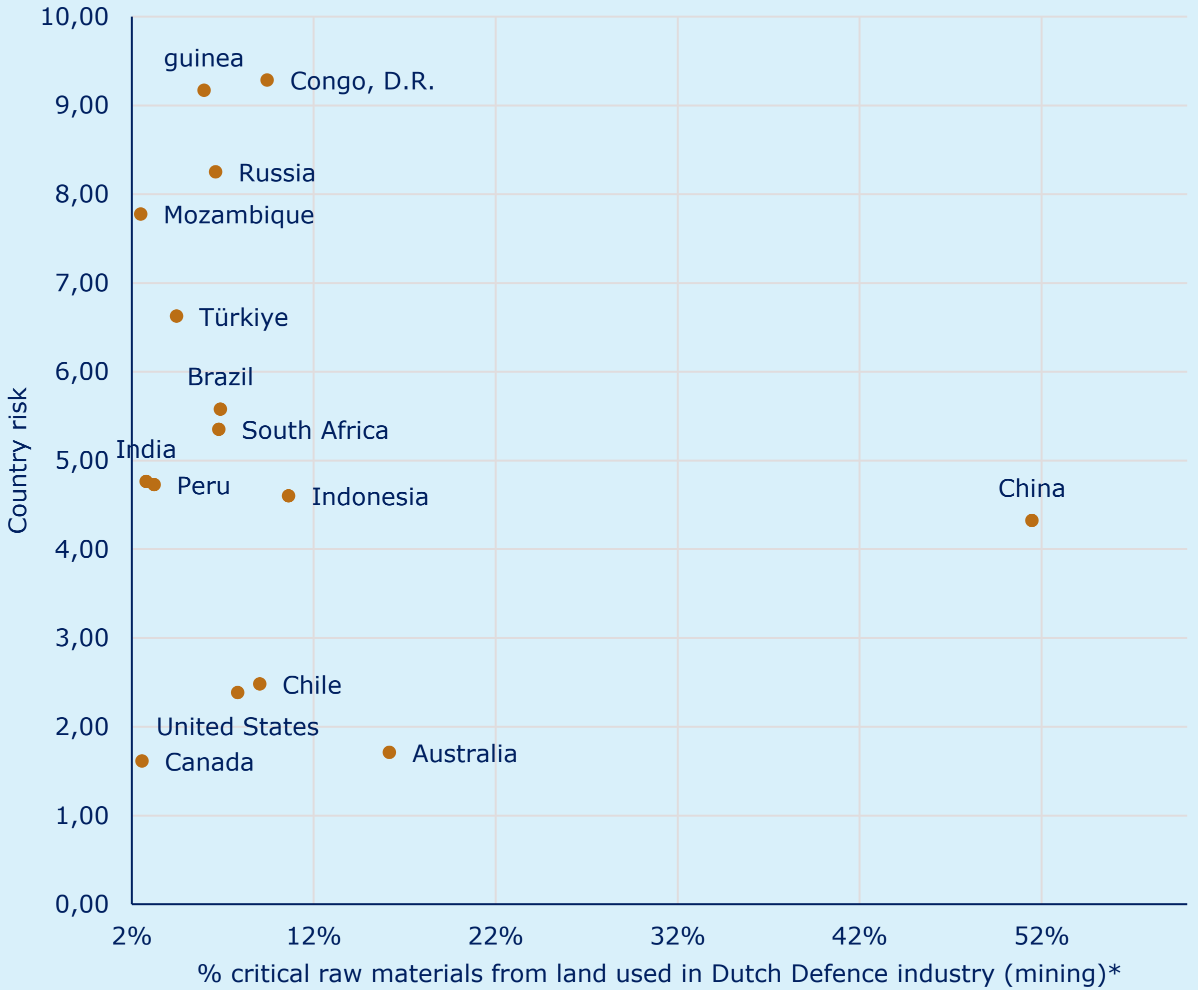
Country risk

SUPPLY RISK ANALYSIS CHAINS

High share of critical raw materials used originate from China

- The graph shows where mining of critical raw materials used in the Dutch defence industry takes place, by percentage of use. For mining, world totals have been used because mining of defence-specific products is not known.
- The critical raw materials used in particular are mined in China (aluminium, magnesium and titanium), Australia (aluminium and lithium) and, to a more limited extent, Indonesia (nickel). The production sites of nickel in Indonesia are joint ventures with Chinese companies.
- High-risk countries where relatively large numbers of used critical raw materials are produced are Congo (cobalt) and Russia (vanadium and platinum metals).
- For germanium, among others, plants are established outside China, including Malaysia, to avoid or work around China's germanium export ban.
- Companies in Indonesia are in some instances owned by Chinese companies.
- Mining facilities in Congo are often part of Chinese or Russian companies.

Location mining critical raw materials used in the Defence industry
Threshold value use: 2%



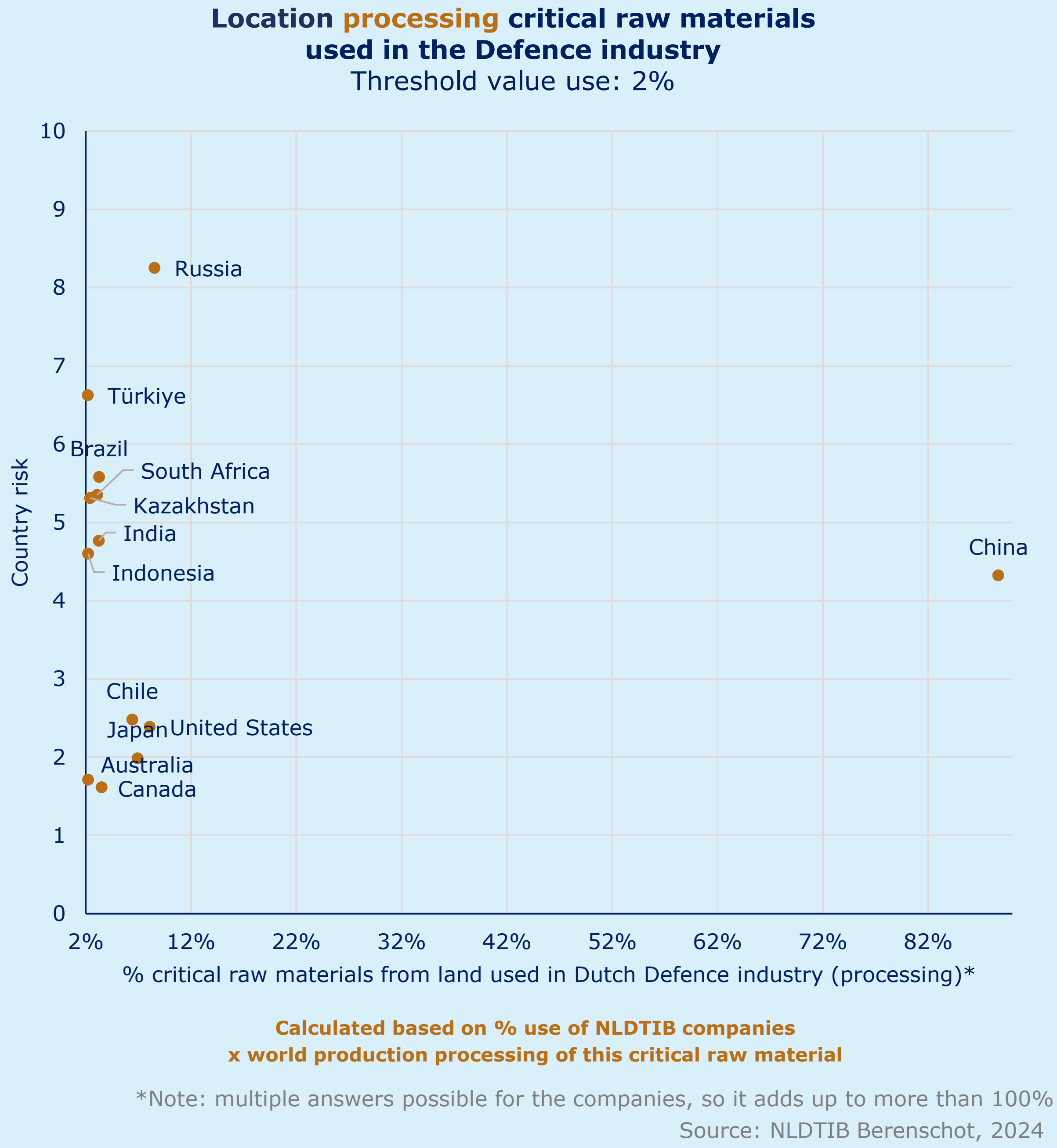
Calculated based on % use of NLDTIB companies x world mining production of this critical raw material

*Note: multiple answers possible for the companies, so it adds up to more than 100%

Source: NLDTIB Berenschot, 2024

High share of used critical raw materials are processed in China

- The graph shows where processing of critical raw materials used in the Dutch defence industry takes place, by percentage of use.
- For processing, world totals have been used as processing of defence-specific products is not known.
- Processing of raw materials used in the Dutch defence industry mainly takes place in China. In particular aluminium, copper and magnesium are processed in China.
- With regard to Russia, aluminium and titanium are processed in particular.



Strong dependence on the United States, especially for the aerospace domain

- The United States has a strong defence industry. Most of the equipment used by the Dutch Ministry of Defence is imported from the United States. The Dutch Ministry of Defence buys many weapon systems directly from the United States. As a result, US chains are important.
- Internationally, the US Ministry of Defence is actively pursuing policies aimed at reducing critical raw material risks. Through stockpiling managed by the Defense Logistics Agency Strategic Materials (DLA SM) and the use of the Defense Production Act (DPA) and the National Defense Authorisation Act (NDAA) supports in the extraction and processing of critical materials.
- Companies in the Dutch defence industry are (highly) dependent on the United States in several areas. In particular, the aerospace domain has a strong dependence on the United States. There is desire from the companies for more transparency regarding the value chains and policies of the US government and US companies.
- Many high-tech components used in defence applications in the Netherlands originate from the United States.
- There are also concerns about the supply of electronics. Electronics from the United States are subject to various restrictions. It is highly complex as the United States wants to export some electronics only under very strict rules, such as motors and encoders for positioning.
- The strict US ITAR regulations are an incentive for companies to reduce dependence on US supplies.
- The interviews show that the limited willingness of the United States to export electronics, for example, is an important motivation for many companies to become less dependent on American suppliers.
- Strict regulations create complexity in the supply chain and regularly lead to delays in deliveries.

Source: Rand Europe; White House B uilding Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth (2021); Congressional Research Service (2022); Rand corporation - Time for Resilient Critical Mineral Supply Chain Policies (2022); USGS Mineral Commodity Summaries (2024); European Commission supplementary chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study (2023).

China is a dominant player in critical materials supply chains

- Over 30 years the Chinese government has been investing in consolidating their control and power over a number of supply chains of critical raw materials, especially (but not exclusively) in rare earths. The Swedish Defence Research Agency (FOI) concluded that of 16 of the EU's strategic raw materials, seven come mainly from China.
- China is well positioned in terms of geography and geology, as well as domestic ownership of raw material reserves and processing capabilities. Moreover, China has been investing in global networks and ownership of mines and critical infrastructure across Africa, the Americas and Europe for many years. For example, although the majority of cobalt mines are in the Democratic Republic of Congo, China owns about two-thirds of them, as well as 60% of global cobalt processing capacity.
- Since August 2023, gallium and germanium – among others important in the production of semiconductors and night-vision equipment - have been on the list of Chinese export restrictions. There is also a Dutch import ban on germanium from Ukraine due to the war. Chinese companies are currently setting up germanium processing plants in Malaysia and elsewhere to avoid the export ban on Chinese germanium. There are doubts among Dutch companies whether the germanium they buy in processed form does not come from China after all, despite a clean ‘paper trail’.
- Companies appear to be heavily dependent on China with regard to value chains and critical raw materials.
- Dutch companies in the defence industry prefer not to buy from Chinese suppliers but do depend on producers further down the chain that are China based. For instance, a large part of electronics comes (indirectly) from China. There is also significant dependence on China for ballistic protection products.
- In addition, Dutch companies in the defence industry are under pressure from Chinese competition. Companies experience that China offers materials below cost price.
- In December 2023, China imposed export restrictions on technologies required to process rare earths. In the past, China has also introduced export restrictions on graphite and other materials.
- Within the semiconductor chain, there is dependence on China for a number of critical raw materials, such as tungsten and vanadium. The quantities are relatively small. Companies try to mitigate risks by diversifying suppliers.

Source: Rand Europe; The White House (2021); RAND corporation Critical Materials: Present Danger to U.S. Manufacturing (2013); Manufacturing Vulnerabilities: Chinese minerals, semiconductors and green technologies in the EU(2024); HCSS Strategic raw materials for defence: Mapping European industry needs (2023).

The United States and the EU are increasingly active in critical materials supply chain policies

- The United States is proactive in driving policies towards critical raw materials. For example, through establishing strategic stockpiles, extending lifetimes and increasing mining and processing capabilities.
- The United States‘ existing dominance in the global defence export market allows it to exercise broad control over partners' supply chains, such as through International Traffic in Arms Regulations (ITAR). Continuing to understand and monitor US policy is therefore a top priority for the Netherlands.
- EU activities in this area have so far mainly focused on the supply chain in relation to the energy transition. The United States and the EU are among the members of the Mineral Strategic Partnership, which aims to work together to ensure the supply of critical materials, especially those critical to the ‘energy transition' (International Energy Agency: IEA).
- However, the new emphasis on the EU-wide industrial defence strategy may change this.
- NATO plays an important role in coordinating efforts.
- So far, NATO has had limited activity on critical materials. However, NATO's Strategic Concept accommodates focus on critical materials and its effect on defence supply chains.
- NATO's Strategic Concept explicitly calls on allies to raise awareness, increase resilience and preparedness, and protect against coercive tactics by countries which divide the alliance. Strategic vulnerabilities and dependencies should also be reduced, including with regard to critical infrastructure, supply chains and improving energy security.
- Finally, to this end, the concept calls on members to enhance their ability to withstand strategic shocks and disruptions to ensure the continuity of the Alliance's activities.
- All these areas of focus provide visible scope for NATO to work on the coordination and coherence of policies related to critical resources.

Source: Rand Europe; Atlantic Council Report - Implementing NATO's Strategic Concept on China (2023); HCSS Strategic raw materials for defence: Mapping European industry needs (2023); IEA Minerals Security Partnership (2022); NAVO Strategic Concept (2022).

The policy on critical raw materials and materials must be viewed in a broader international context

- The availability of critical raw materials and materials not only relates to the defence industry, but also to broader economic aspects and national security. These include energy, critical infrastructure and civil technological developments. These are vital processes and sectors as recognised in the National Security Strategy.
- The energy transition appears prominently in many policy documents in relation to global supply chain requirements and critical raw materials bottlenecks.
- Critical raw materials and materials are also crucial in technology and commercial sectors. Semiconductor production, for example, is critical to many key sectors. This means that policies on critical raw materials and materials should be considered in a broader international framework.

- The United States is placing increasing emphasis on increasing stocks of critical raw materials due to the energy transition and concerns about defence supply chains, (U.S. Geological Survey 2024).
- The United States has introduced financial incentives for the mining and processing of critical raw materials, such as tax breaks. See, for example, the CHIPS and Science Act as well as the Inflation Reduction Act. The EU's new Critical Raw Materials act is an important first step towards coordinating EU activities.
- It will take time for US and EU investments in mining, processing and stockpiling to be effective. Developing stockpiles and mining and processing capacities require significant lead time. In addition, there are ecological and social bottlenecks with regard to starting mining operations.
- Thus, the Netherlands is currently exposed to a period of high risk.

Source: Rand Europe; Manufacturing Vulnerabilities: Chinese minerals, semiconductors and green technologies in the EU; Junerfält and Wannheden (2024); European Commission (2023a); European Commission (2023b); White House (2021); White House (2022); HCSS Strategic raw materials for defence: Mapping European industry needs (2023) Rand corporation Relationships between the economy and national security: Analysis and consideration for economic security policy in the Netherlands. (2020). USGS (2024), Center for Strategic and International Studies (CSIS) - Mineral Demands for Resilient Semiconductor Supply Chains (2024), Europese Unie European Critical Raw Materials Act (2023).

Berenschot

8. Mitigation strategies and measures

Dependencies, risks and measures regarding the use of critical raw materials within the DIS domains

Identification of mitigation strategies and measures

- Previously the critical raw materials used per domain and DIS area, its value chains and dependencies and the associated risks have been identified. To mitigate these risks, an analysis of possible measures and actions is made.
- From the questionnaire among NLDTIB companies, the measures taken by companies regarding critical raw materials are identified. The first part of this chapter gives an overview of the measures taken per domain and chain position, and which possibilities there are for companies to take measures.
- This is followed by an indication for the actions in respect to the government as well as companies, where a priority is also given.
- Below are a long list of measures, clustered by actions for the government, the sector and individual companies.

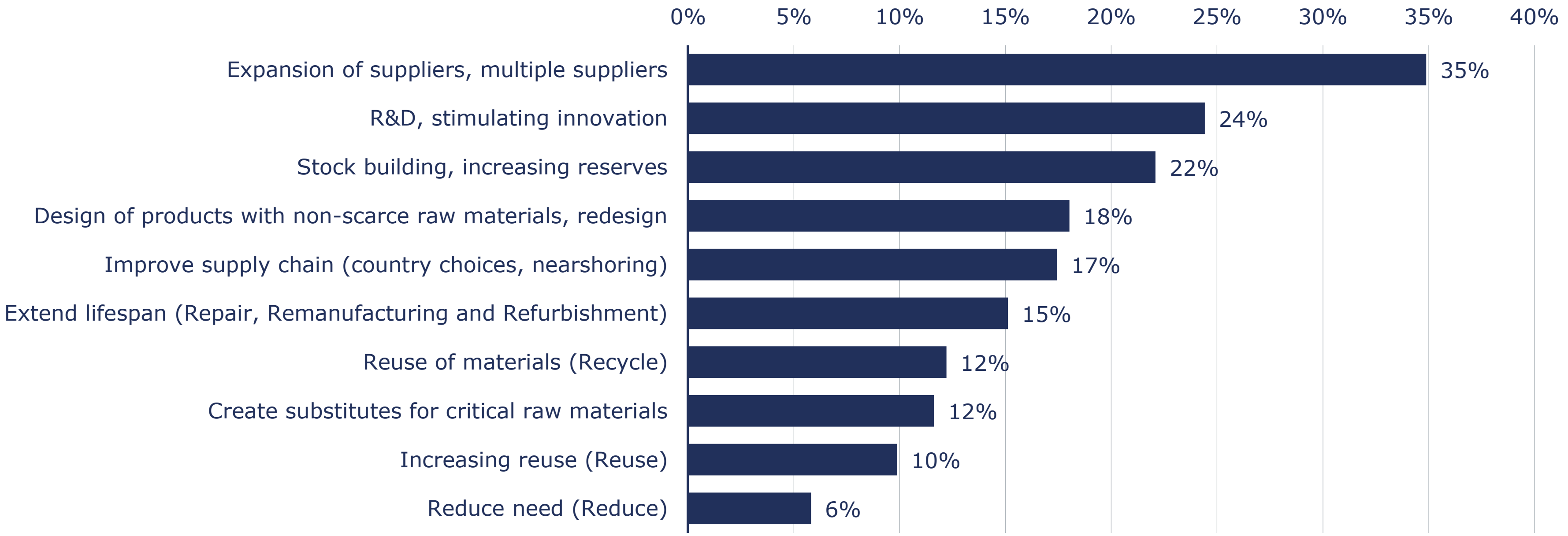
Cluster	Strategy	Measure
Long term strategy Government	Country collaborations	Invest in and improve or strengthen the countries with an abundance of raw materials to diversify the supply, invest in local mining within Europe. Agreements with suppliers and exploring alternatives together with the EU
	Restrictive measures	Export quotas, export taxes, licenses, ownership structure, takeover restrictions, trade agreements
	Incentives	Strengthen companies, subsidy
Stimulate chain cooperation between companies and sectors	Industrial cooperation and ecosystems between and within domains	Horizontal and vertical cooperation. action plan for synergies between civil, Defence and space industries
Create substitutes	Broaden supply chain	Expansion, broadening of suppliers, country choices, nearshoring
	R&D, stimulating innovation	Design of products with non-critical raw materials, redesign
Reduce need	Reduce, Reuse, Repair, Recycle, Remanufacturing and refurbishment	Reduce materials through waste collection, reuse, recycle, extend lifespan
Stock building	Increase reserves	Strategic stockpiling to solve short-term bottlenecks

Source: Critical Raw Materials Act ; Letter to Parliament about National Raw Materials Strategy Raw materials for the major transitions annex-national raw materials strategy, December 9, 2022; FME letter to Parliament on raw materials strategy Commission June 21, 2023; SER - Balanced management of the raw materials transition and the energy transition for broad prosperity September 2022; HCSS Securing Critical Materials for Critical Sectors Policy options for the Netherlands and the European Union, December 2020.

Risks regarding critical raw materials are mainly mitigated by dual-sourcing, R&D and stockpiling

- Companies work to mitigate supply chain risks of critical raw materials but find it difficult to get a grip because raw materials are sourced and processed further upstream in the chain.
- When companies supply OEMs, there is little room for R&D and redesign.
- Broadening suppliers (dual sourcing) is mentioned most often by companies to mitigate dependencies and risks.
- Stockpiling, boosting upstream R&D/innovation and optimising supply chains are mentioned relatively often. Recycling, substitutes, reuse and reduce are less relevant due to the nature of the products purchased by the Dutch defence industry.
- In-depth interviews show that a significant part of the measures below are taken to ensure production security in a broad sense, mitigating risks related to critical raw materials are part of this.

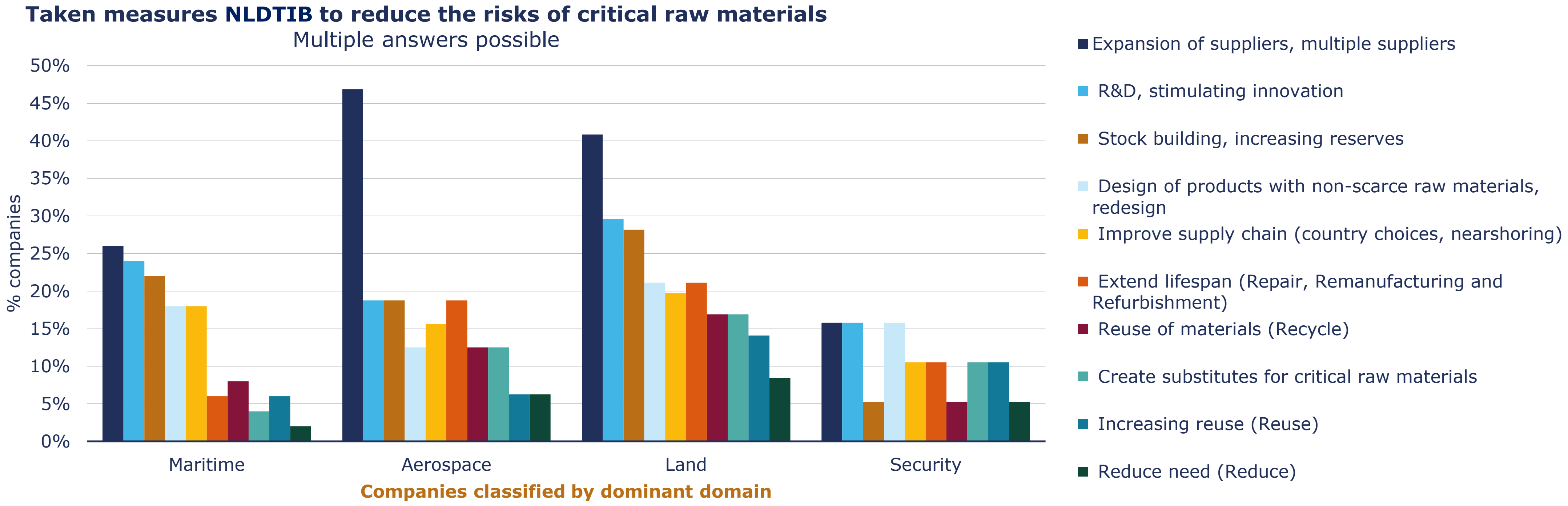
Taken measures NLDTIB to reduce the risks of critical raw materials
Multiple answers possible



Source: NLDTIB Berenschot, 2024

The land domain NLDTIB takes the most measures, maritime and security the least

- The aerospace domain chooses most to broaden the number of suppliers.
- The land domain takes the most measures, especially with regard to R&D but also stockpiling.
- The maritime domain focusses relatively strong at designing products with non-scarce raw materials.



Source: NLDTIB Berenschot, 2024

Limited space within the aerospace domain for taking measures

Companies in the aerospace domain are mostly part of international supply chains, in particular supply chains in the United States where many OEMs are located. OEMs set strong standards when it comes to materials, quality, production processes as well as choice of suppliers, among other things.

- There is a lot of licensed production where US OEMs are ‘design authorities’ and enter into agreements with suppliers to have parts produced. The OEM decides from which suppliers upstream in the chain the parts should be sourced. Because no deviation from the prescribed suppliers is allowed, there is no incentive for companies to further explore the chain upstream.
- Making independent choices regarding production materials and processes or suppliers, and thus the use of critical raw materials, is very limited within this domain.
- Companies indicate that bargaining power towards large OEMs is limited. Dual-sourcing takes place to a limited extent due to strict regulations from the OEMs. Stockpiling takes place in connection with contractual obligations, with raw material suppliers already having limited stocks due to arisen backlogs.

Moreover, being tied to certifications (e.g. regarding high pressure and heat resistance) requires significant investments when changing suppliers.

- It means going through a multi-year and complex certification process, which comes down to making a new business case. This also applies, for example, to the application of 3D printing, which aims to avoid waste and produce parts quickly.
- Products therefore need to be redesigned, which also brings new certifications and associated costs. Innovation is therefore difficult.

Land domain takes limited actions, mainly for scaling up or product improvement

Companies in the land domain take limited action.

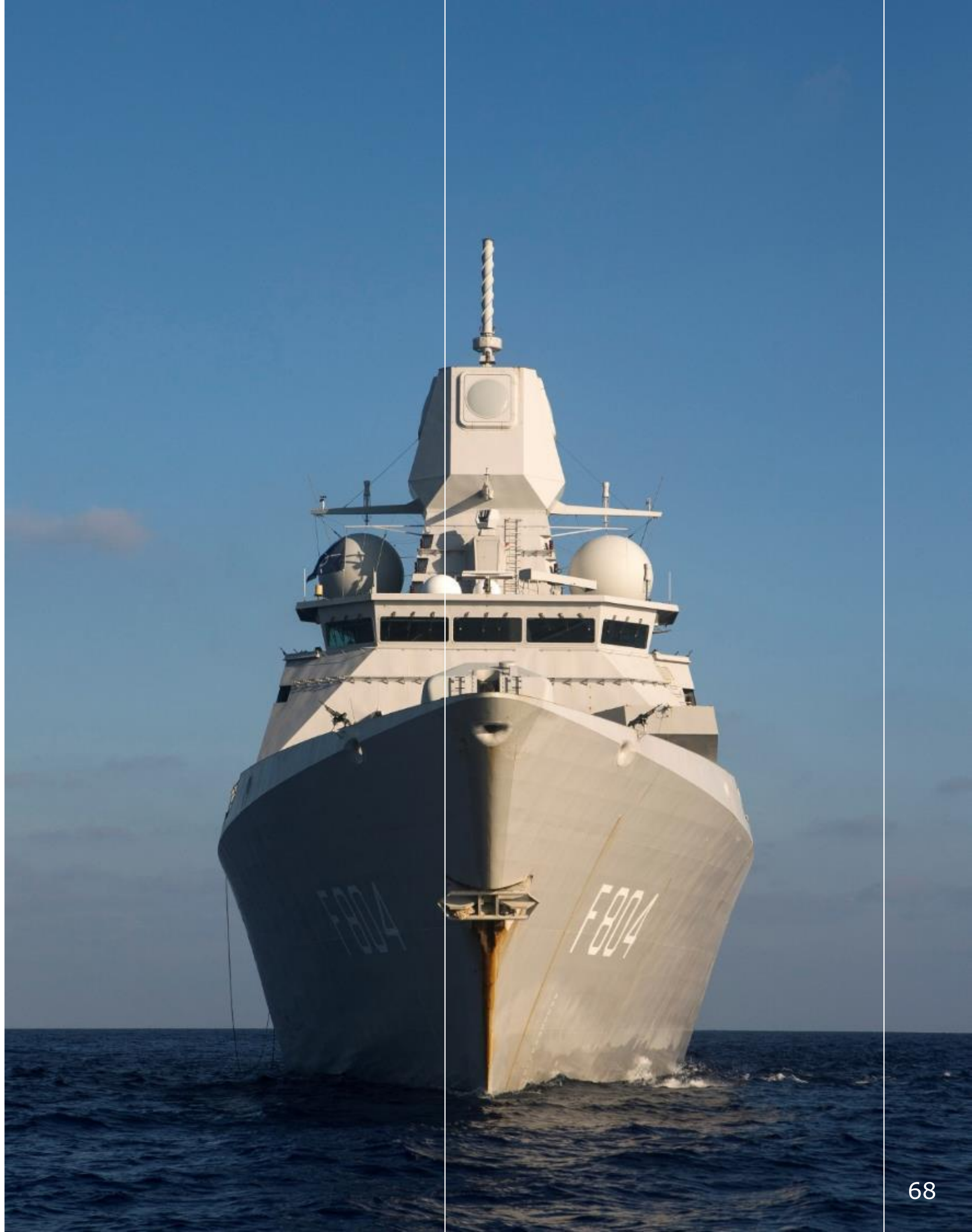
- Research and development, innovation and reducing the use of critical raw materials mainly takes place from the perspective of logistics, delivery reliability or product improvement, e.g. to reduce weight and improve performance.
- Substitutes are more often available: products are less complex, or alternatives are available. However, this does mean significant investments to adapt products to other materials.
- Companies are engaged in dual sourcing, but mainly to scale up. This is because suppliers have limited capacity due to the increase in demand. In some cases, however, there are limitations for companies that are part of international groups, because purchasing is centralised and freedom of choice is limited.
- Also, being tied to certifications requires significant adjustments when changing suppliers: going through a multi-year and unruly certification process and basically making a new business case. In the land domain, this also occurs, but to a lesser extent than the air domain.

Limited attention and measures within the maritime domain

- Traditionally, the maritime domain has had a strong presence in the Netherlands. A significant part of the value chain is present in the Netherlands.
- Since many parts of ships originate from the civil domain, civil applications are used to a large extent for the manufacturing of Defence equipment. Defence-specifically, the communication and weapon systems differ from civilian ships, the latter of which are not produced in the Netherlands.

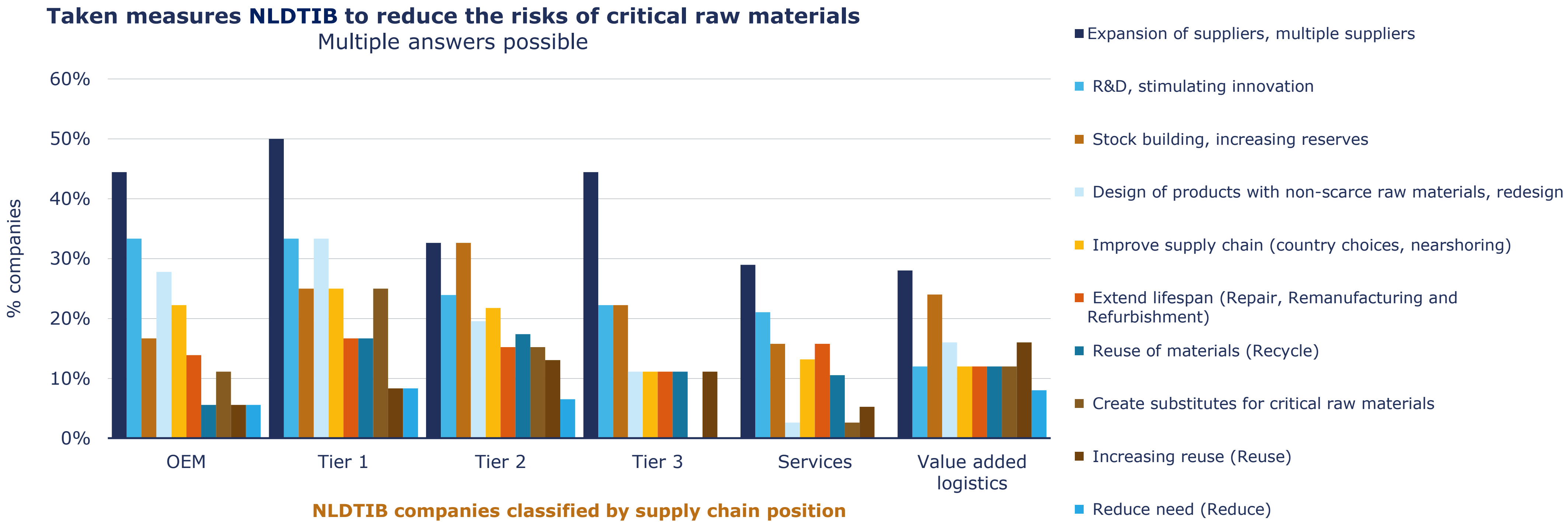
To a limited extent measures are being taken by defence companies.

- Due to the limited use of critical raw materials and the fact that it is not known which critical raw materials are incorporated in components, limited action is taken.
- There is such large choice in suppliers, partly due to the dual-use nature of the maritime domain, that urgency is felt to a limited extent. Improving the supply chain is only to reduce dependence on a single supplier.
- Measures are taken almost exclusively from a commercial point of view.
  - The increased desire for strategic autonomy has put more pressure on European suppliers, resulting in scarcity and higher prices. Therefore, companies are working on dual suppliers.
  - From an efficiency point of view, the use of steel, among other things, is being reduced.
- It is also indicated that it is difficult to set different requirements given the commercial process, where the question is whether you want to have influence as a customer.



Tier 1 companies NLDTIB in particular are taking measures to reduce risks of critical raw materials

- Tier 1 companies take most measures especially regarding suppliers.
- Reduce, recycle and reuse of materials is applied by few companies. This is possibly due to the fact that mostly semi-finished products are purchased, which cannot be easily reused.
- Service providers, trading companies and tier 3 companies take relatively fewer measures regarding critical raw materials.
- The survey shows that growing companies in particular are taking measures. These are often situated in high-technology areas.



Source: NLDTIB Berenschot, 2024

High-tech and semiconductors: reducing the use of critical materials and dependence on China is high on the agenda

High-tech products (robotics, sensoring, etc.) tend to have a complex (critical) materials mix. Within the high-tech and semiconductor industry, reducing dependencies on third countries and critical raw materials is high on the agenda.

- Companies in the high-tech industry work intensively on reducing risks by broadening the number of suppliers. Dual sourcing is common practice; in addition, R&D is also important. There are few opportunities for recycling by sourcing sub-components.
- Establishing intermediate stocks of sub-components is seen as the only short-term solution, although, on the contrary, companies generally want to reduce inventories. Standardisation helps to build stocks, although the risk then is that if one sub-component is not available, nothing can be made.
- Redesign is very costly and takes a lot of lead time and effort. Nevertheless, interviews show that companies are speeding up innovation projects for new product design to stop being dependent on Chinese suppliers. Companies are working on building new supply chains outside China and Taiwan. There is a focus on Malaysia, Japan and South Korea.
- Some companies want to become less dependent on the US because of ITAR regulations or for competitive reasons. For example, European customers sometimes ask for products whose components are not ITAR-subject. Among past experiences are order returns and delivery delays, with major consequences for the downstream chain.
- In the semiconductor industry, both reducing the use of critical materials and reducing Chinese dependence are high on the agenda. Although reducing Chinese dependence for materials is very complicated, reducing use of critical materials is a strategic issue among advanced semiconductor manufacturers. Pre-competitive research is being conducted in this area. Nevertheless, the performance improvement of the semiconductor industry is still much more important than reducing the use of critical materials, the interviews reveal.
- For the sake of production security, semiconductor manufacturers are leading the way in mitigating (supply chain) risks. Risks related to critical raw materials are an important element. Dual sourcing is the standard, as well as frequent and intensive contact with supply chains to mitigate risks. Moreover, the chain is very closely monitored by the chip manufacturers.

Recommendations for government and companies

- In the following pages outline recommendations for the government as well as for the companies. The overview of possible measures, as shown earlier in this chapter, has been used as a starting point for this.
- Primarily, cooperation between countries should be stimulated because of the strong dependence on international supply chains and it is desirable to encourage companies to identify dependencies and risks, as there is still limited understanding and urgency. Action can then be taken on the additional identified risks.
- These primary measures are specifically and more fully explained.

More country cooperation and identifying business dependencies is a priority

Encourage more country cooperation to reduce risks

- Value chains are strongly international. The Netherlands has a limited number of OEMs, has no mining and processing of (critical) raw materials and therefore mostly imports and exports components and semi-finished products. This makes it highly dependent on other countries for taking measures, especially Europe and the United States. Dutch companies have a limited influence to reduce risks.
- European cooperation and coordination is needed. Various measures are already being taken in Europe with regard to semiconductors. For the use of critical raw materials in the defence industry, measures are still very limited, partly because dependencies are often still unknown and awareness is limited. A supply chain approach is needed, where firstly vulnerabilities are identified and then integral measures, such as broadening suppliers and stimulating innovation, are promoted. In doing so, explore whether European investments can be made in mining and processing in friendly countries, or whether friendly countries can be encouraged to mine and process.
- OEMs are strong standard setters, making companies (especially in the aerospace domain) dependent on the United States for reducing dependencies and vulnerabilities. The United States is ahead in the raw material discussion, but cooperation and coordination with foreign OEMs is needed to give Dutch companies room to reduce dependencies.

Encourage companies to map dependencies and reduce vulnerabilities

- Companies indicate that the discussion with regard to critical raw materials is still in its early stages. There is limited insight into value chains and it is not always known which critical raw materials are incorporated in components. Vulnerabilities, both company-specific and for the broader value chains, are therefore still often unknown, which also limits the measures that can be taken.
- Value chains need to be mapped. Companies can be encouraged to do so. In this way, vulnerabilities will become visible and measures can be taken to address them.
- Many companies do not know exactly which critical raw materials are processed in components. This point is strongly linked to mapping the value chains; only when vulnerabilities are visible can dependencies be reduced.
- When vulnerabilities and risks in the value chains and components are known, companies should be encouraged to reduce them: think of, in particular, broadening the number of suppliers, creating substitutes and reducing the need, for instance by stimulating innovation and reuse.
- Analyse the supply chain risks regarding energetic materials and the role of the chemical supply chain. Energetic materials and other hazardous substances are used in a wide range of products such as propellants, explosives, pyrotechnics, gas generators and in industrial processes and products in which hazardous substances are used.

The role of NATO and the EU is highly important in limiting dependencies on critical materials

- The Netherlands should align its policies on critical raw materials and materials with policies of other EU partners as well as the United States.
- Dutch companies themselves use few critical raw materials and have limited influence to reduce risks regarding shortages. The Netherlands has few opportunities to set up independent mining operations due to geographical limitations. Collective action through the EU or NATO will have the most impact for the Netherlands.
- The Netherlands can act at NATO level by understanding where there are joint dependencies and where they are unique, helping to direct investments and efforts.
- This research shows that critical raw materials of concern to the Netherlands as a defence industry are not necessarily the same as the strategic raw materials included in the EU or US list of critical materials. Boron and copper are of concern to the Netherlands, but this is not listed as a critical material by the United States. At the same time, silicon metal and tungsten are of less concern to the Dutch defence industry but are both listed as EU CRMs and US critical materials. This may have implications for policy priorities from the Netherlands regarding critical materials.

Source: RAND Europe

Government long-term strategy recommendations

Cluster	Strategy	Measure	Recommendations for the Dutch government
Long-term government strategy	Country collaborations	Invest in and improve or strengthen the relationship with countries with raw materials to diversify the supply. Also invest in European mining. Make agreements with suppliers and the EU to investigate alternatives	In line with the European Critical Raw Materials Act, put the subject of critical raw materials higher on the EU-agenda and on NATO-level and seek closer connections with the industry within the EU: • International research at value chain level to reduce dependencies. • In joint European tenders, include the topic of critical raw materials in procurement rules/sustainability requirements. • Making agreements with the United States on possible solutions to ITAR-related complexity. • Explore opportunities for developing a closer relationship and enhanced cooperation with European friendly countries that mine and process critical raw materials, including Australia, Japan and South Korea. • Explore investments in mines within Europe or befriended third countries as agreed in the European Critical Raw Materials Act.
	Restrictive measures	Export quotas, export taxes, licenses, ownership structure, takeover restrictions, trade agreements	• The various trade flows of critical raw materials and components in which they are incorporated should be better mapped, making it more transparent where vulnerabilities are present and possible restrictive measures can be taken. This should preferably be done at EU level. Negative effects, such as unnecessary trade barriers, should also be avoided. • Conduct further investigation into the underlying ownership structures of the 'ultimate beneficial owner' of Dutch companies. The main question should be: who are the ultimate shareholders of the entities at company level and what is their share?
	Incentive measures	Strengthen companies, subsidy	• Accept a geopolitical ‘premium’, or extra cost, to reduce strategic dependencies, due to production in the Netherlands. • Strengthen vulnerable supply chains where there is going to be a high risk if companies disappear or if scaling up is necessary. Use a programmatic approach in the value chain to guarantee security of supply and strengthen governance. Link the critical raw materials to the circular manufacturing industry implementation program. • Focus on retaining and possibly attracting specific defence critical companies (to the Netherlands or EU) and make sure they are solidly anchored, so that there is more European grip on the chain.

Recommendations for stimulating companies and sectors

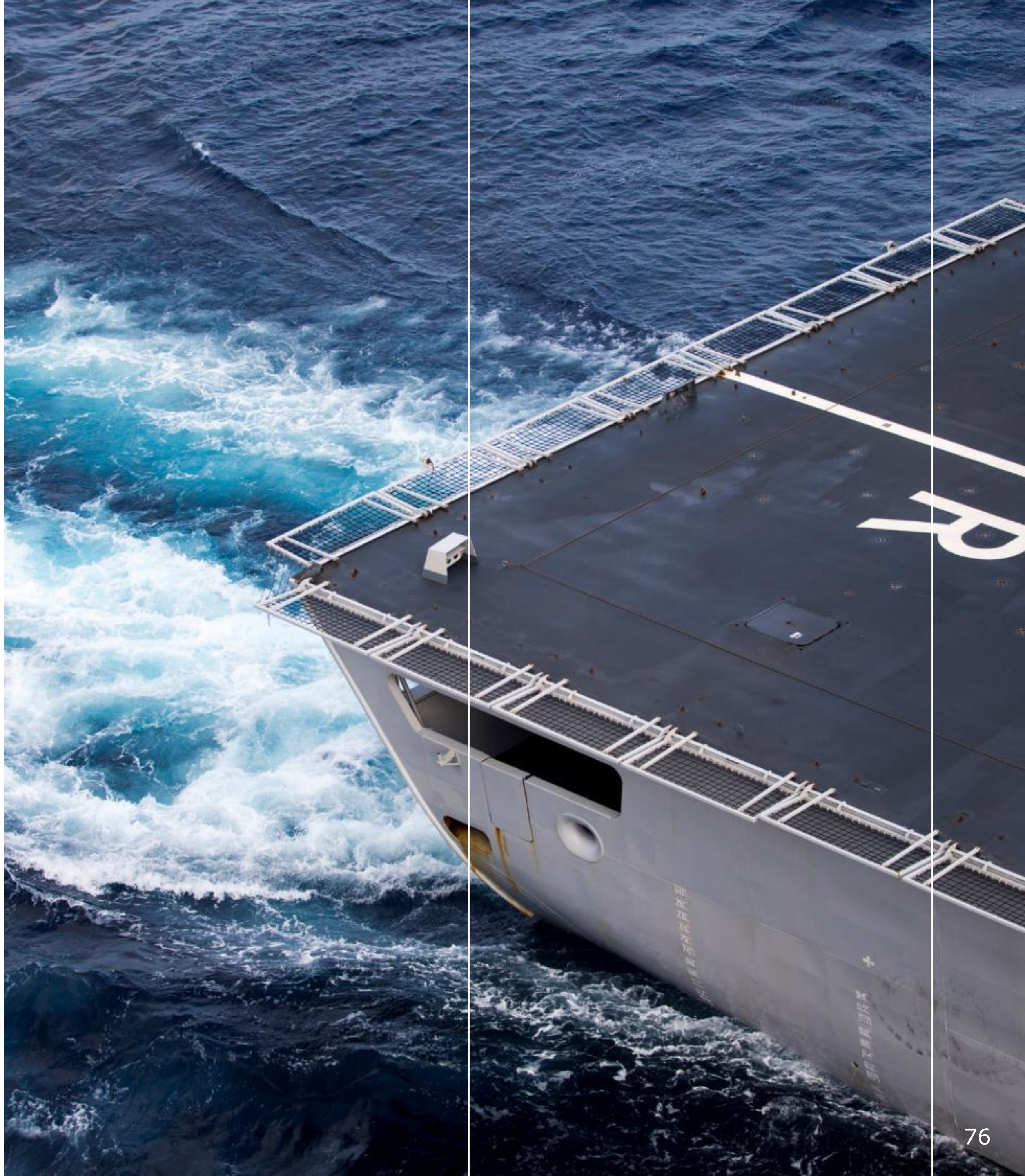
Cluster	Strategy	Measure	Recommendations for the Dutch government
Stimulate chain cooperation between companies and sectors	Industrial cooperation and ecosystems between and within domains	Horizontal and vertical cooperation. Action plan for synergies between the civil, Defence and space industries, but also wider	• Encourage cooperation in and between value chains to mitigate risks from critical raw materials. Innovation clusters in which high-tech companies work together provide a relevant platform for joint research and development within the Netherlands, but also within Europe. • Overall, there is room for improvement when it comes to cooperation between the central government and the defence industry. People need to understand each other better and develop joint initiatives. Think long term.
Create substitutes	Broaden supply chain	Expansion, broadening of suppliers. country choices, nearshoring	• Encourage companies to understand the supply chain and identify risks. Provide a deep dive at specific product groups in which the Netherlands has a leading role, such as in the maritime domain, and at high-tech product groups with a high risk, such as sensors and autonomous systems. • Encourage companies to broaden the supply chain for less dependence on critical raw materials, e.g. support certification of new suppliers.
	R&D, stimulating innovation	Design of products with non-scarce raw materials, redesign	• In line with the National Raw Materials Strategy encourage research into substitutes, for instance through advanced materials or alternative technologies, and innovations aimed at more efficient use of materials. These help ensure both strategic autonomy and leadership for Europe and the Netherlands at global level. • Getting OEMs along who have a driving function from their leading position in the chain is essential. Particularly in the aerospace domain, this measure is difficult due to dependence on foreign OEMs.
Reduce need	Reduce, Reuse, Repair, Recycle, Remanufacturing, refurbishment	Reduce materials through waste collection, reuse, recycle, extend lifespan	• This can be introduced as an extension of the National Raw Materials Strategy, existing sustainability initiatives and (European) regulations such as CSRD.
Stock building	Increase reserves	Strategic stockpiling to solve short-term bottlenecks	• Due to limited direct purchasing of critical raw materials, this measure has limited added value. Companies want to reduce inventories and become more just-in-time. • However, holding stocks for critical components and semi-finished products can be considered instead.

Prioritizing the measures

A first step has been made to score the measures on an assessment framework:

- Impact of the measure on risk, degree to which the risk with regard to critical raw materials is mitigated.
- Time horizon of the measure (short/long term) and possible payback period where applicable. Degree of investment and cost/effort required.
- Complexity of the measure, number of actors involved and social and potential societal impacts.

The measures should be further specified and assessed for legal, operational and political feasibility before it can be converted into policy.



Prioritizing the measures: government

An initial estimate has been made for an assessment framework for government measures. This must be further assessed for legal, operational and political feasibility before it can be converted into policy.

Recommendations for the Dutch government	Impact	Time horizon	Investment	Complexity
• Country collaborations: Put the issue of critical raw materials higher on the agenda in the EU and NATO context and seek closer links with industry within the EU. Seek cooperation with other member states and industry.	Medium	Long	High	High
• Research internationally (at value chain level) to reduce dependencies.	Medium	Short	Low	High
• In joint European tenders, include the topic of critical raw materials in procurement rules/sustainability requirements.	Medium	Short	Low	Medium
• Making agreements with the United States on possible solutions to ITAR-related complexity.	Low	Long	High	High
• Explore opportunities for developing a closer relationship and cooperation with European friendly countries that mine and process critical raw materials, including Australia, Japan and South Korea.	Medium	Long	Medium	High
• Explore investment in mines within Europe or friendly third countries.	High	Long	High	High
• Restrictive measures. The various trade flows of critical raw materials and components in which they are incorporated should be better mapped, making it more transparent where vulnerabilities are present and possible restrictive measures can be taken. This should preferably be done at EU level. Negative effects, such as unnecessary trade barriers, should also be avoided.	Medium	Long	High	High
• Conduct further investigation into the underlying ownership structures of the 'ultimate beneficial owner' of Dutch companies. The main question should be: who are the ultimate shareholders of the entities at company level and what is their share?	Low	Short	Low	Medium
• Accept a geopolitical ‘premium’ to reduce strategic dependencies	High	Long	Medium	Low
• Strengthen vulnerable supply chains where there is going to be a high risk if companies disappear or if scaling up is necessary. Focus on retaining and possibly attracting specific defence critical companies (to the Netherlands or EU) and make sure they are solidly anchored, so that there is more European grip on the value chain.	High	Long	High	High

Prioritizing the measures: companies

An initial estimate has been made for an assessment framework for measures for companies. This must be further assessed for legal, operational and political feasibility before it can be converted into policy.

Recommendations for the Dutch government	Impact	Time horizon	Investment	Complexity
• Encourage cooperation in and between value chains to mitigate risks from critical raw materials. Innovation clusters in which high-tech companies work together provide a relevant platform for joint research and development within the Netherlands, but also within Europe.	Low	Long	Low	High
• Overall, there is room for improvement when it comes to cooperation between the central government and the defence industry. Improve mutual understanding and develop joint initiatives. Think long term.	Medium	Short	Low	Low
• Creating substitutes. Encourage companies to understand the supply chain and identify risks.	Medium	Short	Low	Low
• Encourage companies to broaden the supply chain for less dependence on critical raw materials, e.g., support certification of new suppliers.	Medium	Medium	Medium	High
• Encourage research into substitutes, for instance through advanced materials or alternative technologies, and innovations aimed at more efficient use of materials. These help ensure both strategic autonomy and leadership for Europe and the Netherlands at global level.	Medium	Long	High	High
• Getting OEMs who have a driving function from their leading position in the chain along is essential. Particularly in the aerospace domain, this measure is difficult due to dependence on foreign OEMs.	Medium	Long	High	High
• Reduce need. This can be introduced as an extension of the National Raw Materials Strategy, existing sustainability initiatives and (European) regulations such as CSRD.	Low	Short	High	High
• Stock building. Due to limited direct purchasing of critical raw materials, this measure has limited added value. Companies want to reduce inventories and become more just-in-time. However, holding stocks for critical components and semi-finished products can be considered instead.	Low	Long	High	High

Impact versus effort: government measures

- An initial assessment was made for a consideration framework for measures from the government. These measures are classified low, medium or high on the aspects of impact, time horizon, investment and complexity.
- The graph shows the impact and effort (combination of investment and complexity). The time horizon is indicated by a symbol for each measure.
- Accepting a geopolitical 'premium' and including critical raw materials in tenders are low to medium efforts with a relatively high impact.
- Conducting international chain research and exploring closer relations with friendly countries are measures with medium effort and medium impact.
- The measures need to be further specified and assessed for legal, operational and political feasibility before it can be converted into policy.

Impact versus effort: business measures

- An initial assessment was made for a consideration framework for measures for companies. These measures are classified low, medium or high on the aspects of impact, time horizon, investment and complexity.
- The graph shows the impact and effort (combination of investment and complexity). The time horizon is indicated by a symbol for each measure.
- Encouraging companies to map value chains and improving cooperation between the state and the defence industry are measures with relatively low effort and medium impact.
- Stimulating research into substitutes, getting OEMs (original equipment manufacturers) on board and encouraging and supporting the broadening of supply chains are measures with medium impact but relatively (medium-)high effort.
- The measures need to be further specified and assessed for legal, operational and political feasibility before it can be converted into policy.

Recommendation: prioritize increased understanding of the risks associated with CRM

For the government

In order of priority

1. **Gain a better understanding of the use of critical raw materials and increase understanding of what other countries are doing in this area:**
   - Informing companies about the necessity, urgency and risks to gain insight into dependencies and associated risks.
   - Stimulate international research (at chain level) to gain insight into dependencies and risks.
   - Insight into what other countries are doing regarding critical raw materials in the Defence industry, for example the United States.

2. **Then act on these insights by seeking cooperation and reducing dependencies:**
   - Improve cooperation between the central government and the defence industry. Encourage companies to reduce dependencies and risks.
   - Accept a geopolitical 'premium' to reduce strategic dependencies, for example when including critical raw materials within tenders.
   - Put the topic of critical raw materials higher on the agenda in the EU and NATO context and seek closer links within the EU with other member states and industry.
   - The various flows should be better mapped out, making it more transparent where possible restrictive measures can be applied. This should preferably be done in a European context. Negative effects, such as unnecessary trade barriers, should also be avoided.
   - Explore investments in mines within Europe or friendly third countries and explore closer relationships with friendly countries to reduce dependencies.

For the Defence companies

In order of priority

1. **Improving understanding of value chains and creating awareness of critical raw materials:**
   - Having value chains mapped (by the companies) revealing dependencies.
   - Gaining knowledge on what exactly is in which components and applications.

2. **Get companies to act on vulnerabilities and risks:**
   - Encourage optimisation of value chains, including through dual-sourcing.
   - Reduce dependence on critical raw materials, e.g. by reducing requirements, creating substitutes, recycling materials and redesigning products and components.
   - Include OEMs, which are often decisive.

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Appendix

Dependencies, risks and measures with regard to the use of critical raw materials within the Dutch DIS areas

APPENDIX

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