



Vision on defence related skills for Europe today and tomorrow

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Defence-related skills:

Building evidence on skills shortages, gaps and mismatches and defining the sector's strategy on skills

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Preface

RAND Europe, in cooperation with the Fondazione Giacomo Brodolini, has been commissioned by the European Commission to carry out the project ‘Defence-related skills: Building evidence on skills shortages, gaps and mismatches and defining the sector’s strategy on skills’. The aim of this ongoing project is to help build the evidence base on defence-related skills and deliver a sectoral skills strategy, agreed and validated by stakeholders from across the European Defence Technological and Industrial Base (EDTIB).

This report analyses preliminary findings of the study based on a mixed-methods approach; it will have relevance to stakeholders across the European defence industry, capability planners, and decision-makers responsible for policies relating to skills and the wider defence industrial base in Europe. The report is also relevant to academic institutions, training providers and employers as well as to researchers working in this field. Ultimately, the report aims to lay the foundation for the development of a sectoral skills strategy for the European defence industry in support of a competitive and sustainable EDTIB.

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Abstract

This report presents the European defence industrial skills landscape as part of the twelve-month project on developing a common skills strategy for the European defence sector. The report identifies the skills requirements of the European defence sector, and highlights the skills which will be needed in future, while also identifying the defence market dynamics and technological development trends shaping these requirements. These factors help highlight the drivers of changes in skills needs and scarcity levels, also captured here. This research then identifies defence-related skills gaps and shortages and highlights challenges with different sets of skills, in different defence domains (air, naval, land, space, cyber, complex weapons) and across the stages of the defence equipment life-cycle (e.g. design engineering, manufacture, maintenance, disposal). This report also presents the general features of the European defence industrial skills supply, mapping the existing and planned EU, national, regional, and industry-led policies, programmes and initiatives aimed at the sustainment and development of defence-related skills. This report also identifies strengths and gaps in existing education and training initiatives. It concludes by drawing out the implications of the industrial skills landscape for the European sectoral skills strategy to be developed in the second phase of the project.

Executive summary

The past decade has seen a series of EU policy initiatives focusing on the role of skills as a key ingredient of European defence industrial competitiveness and resilience in supplying the capabilities needed for safeguarding Europe's strategic interests and autonomy (see Figure 0.1 Figure). The skills dimension has been progressively developed in successive policy documents, culminating in the adoption of the European Defence Action Plan (EDAP) in 2016, which outlined the Commission's commitment to support the implementation of measures and initiatives to address defence industry skills needs. In parallel, the Blueprint for Sectoral Cooperation on Skills as part of the New Skills Agenda for Europe has focused on building a strategic framework for cooperation amongst key sector stakeholders in order to address skills challenges across a range of industries. With defence selected as one of the Blueprint pilot sectors, this current project supports the first phases of the pilot: namely, the preliminary identification of skills gaps, challenges and shortages in the defence sector, the drafting of a skills strategy for the sector, and the establishment of a European Defence Skills Partnership (EDSP) to contribute to strategy development and implementation.

Figure 0.1 Overview of key selected EU-level policies



The EDSP brings together 62 experts and stakeholders from across the EU, representing industry, academia, and public authorities. This project has been commissioned by the Executive Agency for SMEs (EASME) for the European Commission – DG GROW and is being delivered by RAND Europe in partnership with Fondazione Giacomo Brodolini (FGB) and supported by the Danish Technological Institute (DTI) and Forum Europe.

Identified skills gaps and shortages within defence industry






The key drivers of the type and volume of skills required by the defence industry are the defence capability programmes, alongside the pace of adoption of new technologies by the European Defence Technological and Industrial Base (EDTIB). Thus, skills needed in the EDTIB fall in two broad categories:

- Skills that enable the delivery of current and planned defence equipment programmes; and
- Skills that enable the industrial base to harness technological advances and remain innovative and globally competitive for the future.

Industry’s visibility into governments’ defence equipment spending plans, export ambitions and corporate provide key signals to education and training organisations regarding the type and volume of skills required. Skills mismatches can arise when there are challenges at any stage of this continuum – from decreasing spending on capability programmes, to insufficient coordination and planning regarding capability plans, to inadequate new skills anticipation mechanism in the educational sphere

While every EU Member State may face its particular constellation of skills challenges in the defence industrial area, **this report identified the following overall areas of skills gaps and shortages in Europe:**

Figure 0.2 Key identified defence industrial skills mismatches in EDTIB

















<p>STEM (science, technology, engineering, mathematics)</p> 	<p>STEM skills gap arises due a high demand in professions like advanced manufacturing, artificial intelligence (AI), electronics, software engineering, radar system engineering and manufacturing cost management.</p>
<p>Cyber and ICT (information communication technologies)</p> 	<p>Digital skills (e.g. software engineering and cybersecurity skills) are increasingly more difficult to source, as the integration of digital technologies in manufacturing processes and equipment designs may requires upskilling.</p>
<p>Management, marketing or sales skills</p> 	<p>The countries with smaller defence industries often report a lack of experience and skills required in management and administration, marketing and sales positions.</p>
<p>Specialised and domain skills</p> 	<p>This gap arises from the limited availability of a pool of potential candidates with the required skills and ageing populations across Europe, the level of interest in working for the defence industry</p>
<p>New skills</p> 	<p>New and emerging technologies (e.g. AI, big data) shape both military capability and industrial process, driving the need for ‘new’ skills.</p>

This report has also demonstrated **there is an overlap between current and near term skills mismatches**, indicating a potential chronic difficulty in sourcing and retaining skills. The reasons behind skills mismatches may vary from **wage competition and lower attractiveness of defence** are seen to drive mismatches for those skills that are more easily transferable from the civil sector; to **low defence demand and demographic challenges** for domain-specific skills that do not exist outside of the defence sector.

Mapping defence related skills landscape in Europe

In addition to EU-level policies, funding instruments and tools in the area of defence skills, the project team identified and reviewed a range of national, regional and company educational and training programmes across a selection of Member States. Divided broadly into ‘top-down’ (public educational programmes, national strategies, policies and initiatives on skills) and ‘bottom-up’ initiatives (industry-initiated skills activities which may be formal or informal in nature and can also include collaboration with government agencies or the education institutions)’ Table 0.1 maps the supply landscape, split by country and by type of initiative.

Table 0.1 Mapping of the skills supply landscape in Europe

Country		DTIB size		Strategy			Identified top-down initiatives		Identified bottom-up initiatives	
		Turnover bn € p/a	Employees	National strategy on skills	Skills focus in defence strategy	Industry/ domain specific	Education programmes relevant to defence industry	Other national initiatives (training, internship, vocational)	Industry-led and internal company initiatives	Collaborative initiatives
Austria		2.5	32,000	x	x	x	✓	-	✓	✓
Belgium		1.5	15,000	x	✓	x	✓	-	-	-
Czech Republic		1.1	15,000	x	✓	✓	✓	-	-	✓
Denmark		0.4	3,000	x	✓	✓	✓	-	✓	✓
Estonia		0.1	-	x	✓	✓	✓	✓	-	✓
Finland		1.4	6,100	x	x	✓	✓	✓	✓	✓
France		15	200,000	x	✓	✓	✓	✓	✓	✓
Germany		30	100,000	x	✓	✓	✓	✓	✓	✓
Italy		16	60,000	✓	x	x	✓	✓	✓	✓
Latvia		-	-	x	✓	✓	✓	-	-	✓
Lithuania		0.1	-	x	x	x	✓	-	-	✓
Netherlands		4.5	24,800	✓	✓	✓	✓	✓	✓	✓
Poland		1	60,000	✓	✓	✓	✓	✓	✓	✓
Spain		5.7	210,000	x	x	✓	✓	✓	✓	✓
Sweden		2.9	63,000	x	✓	✓	✓	-	✓	✓
UK		25.6	265,000	✓	✓	✓	✓	✓	✓	✓

Looking ahead to the European sectoral skills strategy

As the findings of this report set the foundation for the defence sectoral skills strategy, it is important to recognise that a ‘one-size-fits-all’ approach will not be viable. Instead, the approach should focus on **strengthening and adapting the enabling structures** that support industry, public authorities, and education and training organisation in formulating their own skills development and sustainment initiatives, both unilaterally and cooperatively. Specifically, there is considerable scope for **improving resource coordination between defence industry stakeholders, public authorities and academia**. An example may include increased cooperation amongst industry in non-sensitive areas, which are not characterised by large amount of funding. Another approach would be to establish formalised or regularised **programmes for exchanging technical staff and experts** across government and industry, throughout defence industry, and between the defence and civil industry. Involving academia in the dialogue would also help the government and industry to translate strategic medium- and long-term skills priorities into education programmes.

In fact, there are close links **between the defence and civil sectors and between defence and commercial industries**, whether due to many defence firms having prominent civil businesses or a number of key enabling technologies having both military and civil applications. Furthermore, both defence and

commercial employers rely on a common labour pool for the talent they require. A European defence sectors skills strategy will therefore need to suggest ways of enabling and improving the cooperation between civil and defence industries that is necessary to for skills and cross-pollination knowledge-sharing to deliver Europe's future capability needs. Finally, it will be important to improve the attractiveness of the defence sector as an employer to **broaden the diversity of the defence skills base**. Industry, academia, and other national and EU-level stakeholders could work together to address these challenges with awareness-raising workshops, targeted seminars, roadshows and other initiatives.

It is encouraging that several **mechanisms, structures, and funding instruments aimed at enabling and incentivising European collaboration in defence capability development**, such as Permanent Structured Cooperation (PESCO), the Coordinated Annual Review on Defence (CARD) process, and the European Defence Fund (EDF), have emerged in recent years. These can be capitalised on to better incorporate skills development and institute systems and processes for knowledge exchange in the context of collaborative programmes and approaches. In addition, **the EDSP, bringing together representation from the Member States (MS), the industry, and academia, could play an important role** in trailblazing such an effort and sharing good practice and lessons learned.

Conceptual framework and methods

The primary focus of this report is on understanding the nexus where skills demand and supply meet. Depending on whether this results in a match or a mismatch, this can have profound implications for the cost, schedule and quality performance of defence capability programmes and the value-for-money and competitiveness of European industry. Furthermore, the report aims to develop an understanding of what mechanisms help or prevent this matching from taking place.

This report explores the extent to which defence-related skills are currently available to the defence sector, which skills will be needed in future, and where skills mismatches have been observed. It aims to map the skills supply landscape in Europe in order for the next stage of the project to then design pathways to address any identified mismatches. To meet this objective, the project team has analysed and synthesised data from: (1) existing grey and academic literature, (2) 51 expert and stakeholder interviews, (3) an online survey of the European companies, active in defence. The presented findings were also triangulated with the EDSP members during the course of three full-day workshops, and reviewed by the members of an expert Steering Committee assembled specially for this project.

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1. Introduction

1.1. Policy context of this report

The European defence industry is important both strategically and economically, together accounting for a €100 billion turnover and generating 1.7 million direct and indirect jobs.¹ It is also an important driver of innovation across the wider European economy and holds the potential to transfer skills to and from the civil sector.² However, the European Commission is concerned with the skill shortages that companies are experiencing, and expects this trend to increase in the future due to aging demographic and difficulties in attracting and retaining new professionals.³

The subject of defence-related skills in the European context is intertwined with the wider European defence policy landscape. Throughout the greater part of the EU's history and until the mid-2000s, the defence sphere – encompassing operations, armaments policy, and defence industrial aspects – was within the purview of national policymaking, with cooperation taking place within intergovernmental structures, such as the European Defence Agency (EDA) and the Common Security and Defence Policy (CSDP), which provides a mechanism for the EU member states to undertake joint military and civilian missions in support of commonly agreed crisis management priorities. At the same time, the North Atlantic Treaty Organisation (NATO) was the primary vehicle for concerted European action in the military domain. The CSDP came into being in the late 1990s in the aftermath of the post-Cold War conflicts in the Balkans as a vehicle for undertaking autonomous EU action outside of NATO structures. The subsequent establishment of the EDA in 2004 endowed the CSDP with a defence capability development dimension.

Therefore, the adoption of the Defence Package in 2007, in which the European Commission proposed legislative measures to underpin an EU-wide defence equipment market, marked the beginning of the Commission's action on its competence in defence matters. Specifically, the Package proposed two Directives, adopted in 2009, which were aimed at extending the logic of the Single Market (i.e. competition, equal treatment, commonality of standards) into defence procurement and intra-EU defence sales. Since then, the European Commission has been developing European defence industrial policy, in

¹ European Commission. 2017d. 'Blueprint for Sectoral Cooperation on Skills : Responding to Skills Mismatches at Sectoral Level.' As of 28 September 2018: <http://ec.europa.eu/social/main.jsp?catId=1415&langId=en>

² Ibid.

³ European Commission. 2018b. 'Skills in the Defence Sector.' As of 12 November 2018: https://ec.europa.eu/growth/sectors/defence/industrial-policy/skills_en

conjunction with national governments, including through overseeing the implementation of the Directives and promoting cross-border linkages in the defence supply chain.

The European Commission's Communication 'Towards a more competitive and efficient defence and security sector' in 2013 was the first in a series of documents to focus on skills as a component of labour market policy in the defence sector at EU level. The Communication emphasised skills development and sustainment through fostering stakeholder cooperation (Skills Alliances) and facilitating defence industry's access to existing funding instruments to address skills needs. The skills dimension has been progressively developed in successive policy documents – namely, the Communication Implementation Roadmap and Progress report (please see Annex C for a detailed overview of this policy documents and their relevance to skills). An important component of this trajectory was the 2015 study on the initial identification and classification of key skills and competences for the defence sector commissioned by the European Defence Agency (EDA).⁴

In order to leverage the value of existing EU tools to help industry address its skills requirements, in June 2016 the European Commission adopted a New Skills Agenda for Europe, setting out the need for EU Member States to bolster the quality of skills within their respective workforces and align them with the needs of the labour market.⁵ One of the actions launched by the New Skills Agenda is the Blueprint for Sectoral Cooperation on Skills, which focuses on building a strategic framework for cooperation amongst all key sector stakeholders in order to identify skills gaps and develop specific measures to address skills challenges in the context of a sectoral skills strategy.⁶ The Blueprint follows previous European Commission initiatives to establish stakeholder-focused approaches to addressing skills mismatches in various sectors, such as the Sector Skills Councils and the European Sector Skills Alliances. In addition, the EU and Member States' qualitative and quantitative data on skills availability generated as part of the Blueprint process will be consolidated and incorporated into the Skills Panorama and the new Europass Framework. This current project supports the first phases of the Blueprint defence pilot, namely, the assessment of skills gaps, challenges and shortages in the defence sector, the drafting of a skills strategy for the sector, and the establishment of the European Defence Skills Partnership (EDSP) to contribute to strategy development and implementation.

Beyond the economic significance, the European defence technological and industrial base (EDTIB) enables collective European as well as national strategic autonomy, the projection of influence on the international stage, and the defence of European interests and values. As part of a series of efforts and initiatives to bolster the EDTIB, the European Commission adopted the European Defence Action Plan

⁴ Retter, Lucia, Louise Taggart, and Jon Freeman. 2015. *Key Skills and Competences for Defence: Annex E*, European Defence Agency, RR-1226-EDA. As of September 26, 2018: https://www.rand.org/pubs/research_reports/RR1226.html

⁵ European Commission. 2016b. 'A New Skills Agenda for Europe'. As of 21st December 2018: <https://ec.europa.eu/social/main.jsp?catId=1223>

⁶ European Commission. 2017d. 'Blueprint for Sectoral Cooperation on Skills: Responding to Skills Mismatches at Sectoral Level.' As of 28 September 2018: <http://ec.europa.eu/social/main.jsp?catId=1415&langId=en>

(EDAP) in November 2016.⁷ The European Defence Fund (EDF), established under the EDAP, will see the EU allocate a total of approximately €13 billion towards support for collaborative EU defence research and development within the timeframe of 2021-2027, the period of the next Multiannual Financial Framework (MFF).⁸ More directly related to skills, the EDAP also outlined the means by which defence industry could access existing EU funding instruments such as ESIF (European Structural Investment Funds), Europe's Programme for SMEs COSME and Erasmus+, and highlighted the Commission's commitment to:

- Support the establishment of industry-led European defence skills stakeholder cooperation;
- Support the implementation of measures and initiatives to address defence industry skills needs in line with the defence sectoral skills strategy;
- Adopt the Blueprint for Sectoral Cooperation on Skills as the implementing tool;

Since then, in addition to the European Commission, the EDA has been supporting the EDAP objectives by facilitating the access of defence stakeholders – that is, industry, ministries of defence (MoDs), research institutes, and academia – to existing EU funding mechanisms, including ESIF, the new European Defence Fund (EDF), and Erasmus+, including for projects focused on skills development and sustainment.

1.2. Defence industrial skills context in Europe

Across Europe and globally, the increasing pace of emergence and adoption of new technologies, growing global interconnectedness, and demographic change are transforming the nature of work and the workplace.⁹ Although this evolution holds the potential to generate economic growth and new types of jobs, it also requires skilled and qualified talent that can support and thrive in the digitised, automated and interconnected workplace of the future. At the same time, each sector of the economy is facing its own particular challenges in generating, sustaining and developing the needed talent. The defence sector is also not immune from such challenges, and is particularly significant as the enabler of safeguarding and promoting core national and European interests.

As in other sectors, human capital is a dominant production factor. Whether in the conduct of military operations or the production of essential defence technologies and equipment people ultimately underpin defence activities. Without access to the right mix of skills, European nations cannot hope to deliver the military capabilities they need to protect Europe's citizens, interests and values,¹⁰ nor promote Europe's

⁷ European Commission. 2016c. 'European Defence Action Plan: Towards a European Defence Fund'. As of 21 December 2018: http://europa.eu/rapid/press-release_IP-16-4088_en.htm

⁸ European Parliament. 2018. 'European Defence Fund'. As of 21 December 2018: <http://www.europarl.europa.eu/legislative-train/theme-new-boost-for-jobs-growth-and-investment/file-mff-european-defence-fund>

⁹ European Commission. 2017d. 'Blueprint for Sectoral Cooperation on Skills: Responding to Skills Mismatches at Sectoral Level.' As of 28 September 2018: <http://ec.europa.eu/social/main.jsp?catId=1415&langId=en>

¹⁰ European Defence Agency (EDA). 2018. 'Capability Development Plan'. As of 20 December 2018: <https://www.eda.europa.eu/what-we-do/our-current-priorities/capability-development-plan>

strategic autonomy¹¹ in an uncertain and dangerous world. The design, development, manufacture, maintenance, operation, upgrade and disposal of defence equipment are all activities heavily reliant on access to a wide array of skills and competences – some relatively easy to acquire and maintain or transfer from civil industry, but others requiring decades of investment, planning and hands-on experience to build up the requisite levels of deep subject matter expertise. These skills support not only Europe’s military capability, but also promote wider spill-overs, such as innovation or exports, that benefit the broader European economy and society. The strength of any defence technological and industrial base (DTIB) is underpinned by the skills and competences of those working for companies that supply equipment and services in response to governments’ stated capability requirements and defence investments. Ensuring access to relevant skills and competencies, and remaining responsive to wider skills trends, is a challenge facing the defence sector both domestically and on a European level.

In recent years, fiscal pressure on European defence spending and a lack of new acquisition programmes or investment in research and development (R&D) have all contributed to rising concerns over the availability of many of the skills needed for a vibrant and competitive EDTIB. Given the enduring uncertainty around future procurement programmes and a host of other interconnected challenges (such as lengthening product life-cycles, an ageing demographic and growing competition for the skilled workforce from both civil industry and non-European economies), without targeted action, Europe may face difficulty in sustaining the necessary industrial skills base and skills pipeline. Otherwise, it will have to accept painful trade-offs in terms of military capability, industrial competitiveness, and the affordability of defence programmes. Ultimately, the answers found to these questions around the sustainability of Europe’s defence-related skills will help shape Europe’s strategic autonomy and freedom of action on the global stage.¹²

There are various factors that affect the sector’s ability to recruit and retain sufficiently qualified and experienced personnel (SQEP)¹³ and to nurture and maintain their skills sets:

- A steady contractual pipeline from public sector and private sector clients (across the product lifecycle, i.e. involving a mix of design, manufacture and support), creating the demand needed to keep workers employed and, crucially, providing opportunities for hands-on ‘learning by doing’;
- A steady supply of vocational training and education as well as university graduates with relevant degrees interested in entering the defence industry, as either graduates or apprentices;
- A supply of qualified technical experts to satisfy both the defence industry’s continued reliance on manufacturing and the progressive adoption of new technologies that are progressively changing manufacturing processes. This is needed at different levels of experience, that can compensate for the skills and knowledge lost through retirement of older

¹¹ European Union External Action (EEAS). 2016. ‘European Union Global Strategy’. As of 20 December 2018: https://eeas.europa.eu/archives/docs/top_stories/pdf/eugs_review_web.pdf

¹² Retter, Lucia, Louise Taggart, and Jon Freeman. 2015. Key Skills and Competences for Defence: Annex E, European Defence Agency, RR-1226-EDA. As of 26 September 2018: https://www.rand.org/pubs/research_reports/RR1226.html

¹³ Ibid.

experts, or due to natural market churn or turnover of labour, and who can also offer new perspectives, insights and ideas.

According to previous studies, challenges for sustaining key defence skills include: economic and political uncertainty; limited communication between capability planning and the defence industry; the lack of a strategic approach to skills management on a European level, but also across many MS nationally; and a negative perception of the defence sector by some audiences.¹⁴ Although both governments and industry recognise the rising skills gap as a growing area of concern for the EDTIB, aligning incentives across the public and private sector, and coordinating actions at a national and European level, is not a simple task. Chapter 2 provides a detailed characterisation of the linkages between demand for labour and skills in the defence sector, as well as the main factors contributing to skills gaps.

At the same time, Europe's strategic, military and industrial competitors and partners are not standing still. Countries such as the US are continuing to invest in new technologies, products and services, both in support of European militaries as suppliers but also as competitors to European firms in local and export markets. Emerging economies such as China, Turkey or India are investing significant resources in increasing their defence industrial capacity and capability, contributing to a rapid erosion of the traditional technological edge held by Western militaries and industry.¹⁵ Investments in many new technologies, such as artificial intelligence (AI) or industrial robotics, are often being driven by multinational firms headquartered outside of Europe, or by industry players outside the defence sector such as Deepmind and Google.

For the EDTIB to be sustained into the future, the evolving trends of the defence industry in Europe should therefore be taken into account.¹⁶ Manufacturing processes and value chains are expected to change dramatically, for example with the implementation of new technologies such as additive layer manufacturing (otherwise known as 3D printing, where components are constructed by sequentially building up thin layers of material), which will in turn change the volume and composition of the skills requirement in industry. The nature of the military equipment needed, for example with increased

¹⁴ Cauzic, Francois, Helene Colas, Nathalie Leridon, Sofiene Lourimi, and Elisabeth Waelbroeck-Rocha. 2009. 'A comprehensive analysis of emerging competences and skill needs for optimal preparation and management of change in the EU defence industry.' *Eurostrategies*. As of 20th December 2018: <https://www.eda.europa.eu/docs/default-source/procurement/14-cps-op-030-q-a-nr1-annex-1-97-skills-report-vf-1.pdf>; Bekkers, F., M. Butter, E. Anders Eriksson, E. Frinking, K. Hartley, M. Leis, M. Lundmark, H. Masson, A. Rensma, T. van der Valk, and G. Willemsen. 2009. 'Development of a European Defence Technological and Industrial Base.' *European Commission*.

¹⁵ See, for example: Britz, M. 2016. 'Military non-alignment, political solidarity, and a retreat to territorial defence: how to understand the Swedish NATO-debate.' *Norwegian Institute of International Affairs*. As of 27 September 2018: http://www.css.ethz.ch/content/dam/ethz/special-interest/gess/cis/center-for-securities-studies/resources/docs/NUPI_Policy_Brief_17_16_Britz.pdf; and Stockholm International Peace Research Institute (SIPRI). N.d. As of 21st December 2018: <https://www.sipri.org/databases/milex>

¹⁶ European Council. 2013. 'Conclusions of the meeting of the European Council 19/20 December 2013'. As of 21st December 2018: http://www.europarl.europa.eu/meetdocs/2014_2019/documents/sede/dv/sede110914ecconclusionscsdp/_sede110914ecconclusionscsdp_en.pdf

unmanned and autonomous capability driving different requirements into the defence sector,¹⁷ as well as the balance taken between defence exports and imports, could also alter the European skills landscape. This shift from a defence platform focus towards an ecosystem that encompasses systems, technologies, and professional services also highlights the fact that defence skills do not exist in a vacuum but rather are also closely connected to developments in the civil and dual use sector.

1.3. Objectives and scope

This report reflects the work conducted in the first work package of the twelve-month project on defence related skills, funded by the COSME programme. As this ongoing overall project for the European Commission sets out to design and deliver a sectoral skills strategy, the purpose of this report, is to:

- Present the state of play of the types of defence-related skills needed today;
- Consider which skills will be required in the future;
- Identify defence-related skills gaps and shortages;
- Set the scene for designing pathways to address any identified mismatches in the next stage of the project.

For the purpose of this report, a skills gap refers to a “situation where the type of skills of people do not match the requirements of the job or the level of skills is less than the level required to perform the tasks associated with the job satisfactorily,¹⁸ while a skills shortage refers to a “situation in labour market where the demand for particular type of skills is higher than the supply of workers with that type of skill.” In other words, the volume of skills supplied is insufficient to meet the volume of skills demanded by employers.¹⁹

By analysing the factors that determine changes in skills needs, the report aims to identify what makes a skill scarce and identify challenges with different sets of skills, in different defence domains (air, naval, land, space, cyber, complex weapons) and across the stages of the defence equipment life-cycle (e.g. design engineering, manufacture, maintenance, disposal). Covering a wide array of skills initiatives and stakeholders, including small and medium enterprises (SMEs), prime system integrators, national governments, and the European landscape, this report also identifies strengths of existing education and training initiatives and gaps in their availability.

¹⁷ UK Ministry of Defence. 2007. ‘Defence Technology Strategy’. As of 21st December 2018: https://webarchive.nationalarchives.gov.uk/20121021133349/http://www.mod.uk/NR/rdonlyres/27787990-42BD-4883-95C0-B48BB72BC982/0/dts_complete.pdf

¹⁸ CEDEFOP. 2018a. ‘Developments in vocational education and training policy in 2015-17: Poland.’ *Cedefop monitoring and analysis of VET policies*. As of 5 September 2018: http://www.cedefop.europa.eu/files/poland_-_vet_policy_developments.pdf

¹⁹ Ibid.

1.4. Conceptual framework

This report provides a review of the current state of skills demand in the defence sector. Skills are measured using a variety of indicators, including occupation and qualifications, and increasingly through identifying the demand for specific skills (both technical and soft skills). Typically, national governments are interested in understanding the extent to which the supply-side can meet skills demand both now and in the future. Where skills shortages are identified, there is an interest in understanding their cause with reference to market failures of one kind or another. In relation to skills, these may refer to capital market failures (i.e. individuals and sometimes employers do not have access to capital to fund training), information failures (e.g. employers do not see the benefits that can be derived from investing in human capital), risk aversion (employers are unwilling to take financial risk that the investment does not yield sufficient returns), and institutional failures (e.g. training systems are not sufficiently responsive to signals from the demand side). In this way, it is possible to identify where interventions might be needed. In relation to the defence sector, this report will identify a particular set of market failures that result in sub-optimal skills development. Rather than a quantitative delineation of the skills gaps, this report provides a qualitative analysis of secondary and primary data, validated through extensive consultation with experts and stakeholders.

This report defines the “EU defence industry” as comprising of those firms, EU-headquartered firms, both privately and publicly owned, that produce and supply defence equipment to the armed forces and ministries of defence (as opposed to providing services), regardless of whether they are also active in the civil sectors. All sizes of firms are considered, including small- and medium-sized enterprises (SMEs), mid-caps, and original equipment manufacturers (OEMs) and systems integrators. This report focuses on firms across all EU member states and considers, includes programmes at the industry, regional, and national levels. Building on the results and efforts of previous RAND Europe research on key skills for defence in the industrial and governmental domains,²⁰ the research team employed a mixed methodology approach to first further refine and validate a defence industrial skills supply and demand model. This is intended to frame the skills challenge and guide the subsequent analysis.

Visualised through a relationship map (see Figure 1.2 below), it emphasises that the **matching (or mismatching) of defence skills supply and demand occurs in a continuous fashion** and through the complex interplay of a variety of **dynamics and trends**. These are, in turn, influenced by a range of factors, such as **existing and planned equipment programmes (whether for domestic or export customers)**, the shifting dynamics of the **labour market**, the implications of **technological change**, the relevance and availability of **skills programmes**, and the impact of **tools** and initiatives that different actors across government, industry or academia can adopt in an effort to align demand and supply.

²⁰ Retter (2015); Silfversten, E., Flint, R., Lynch, A., Ward, A. & A. Hall. Forthcoming (2018). *Cyber Defence Specialist Models* (CD SpecMods). Prepared for the European Defence Agency. Not for public distribution.

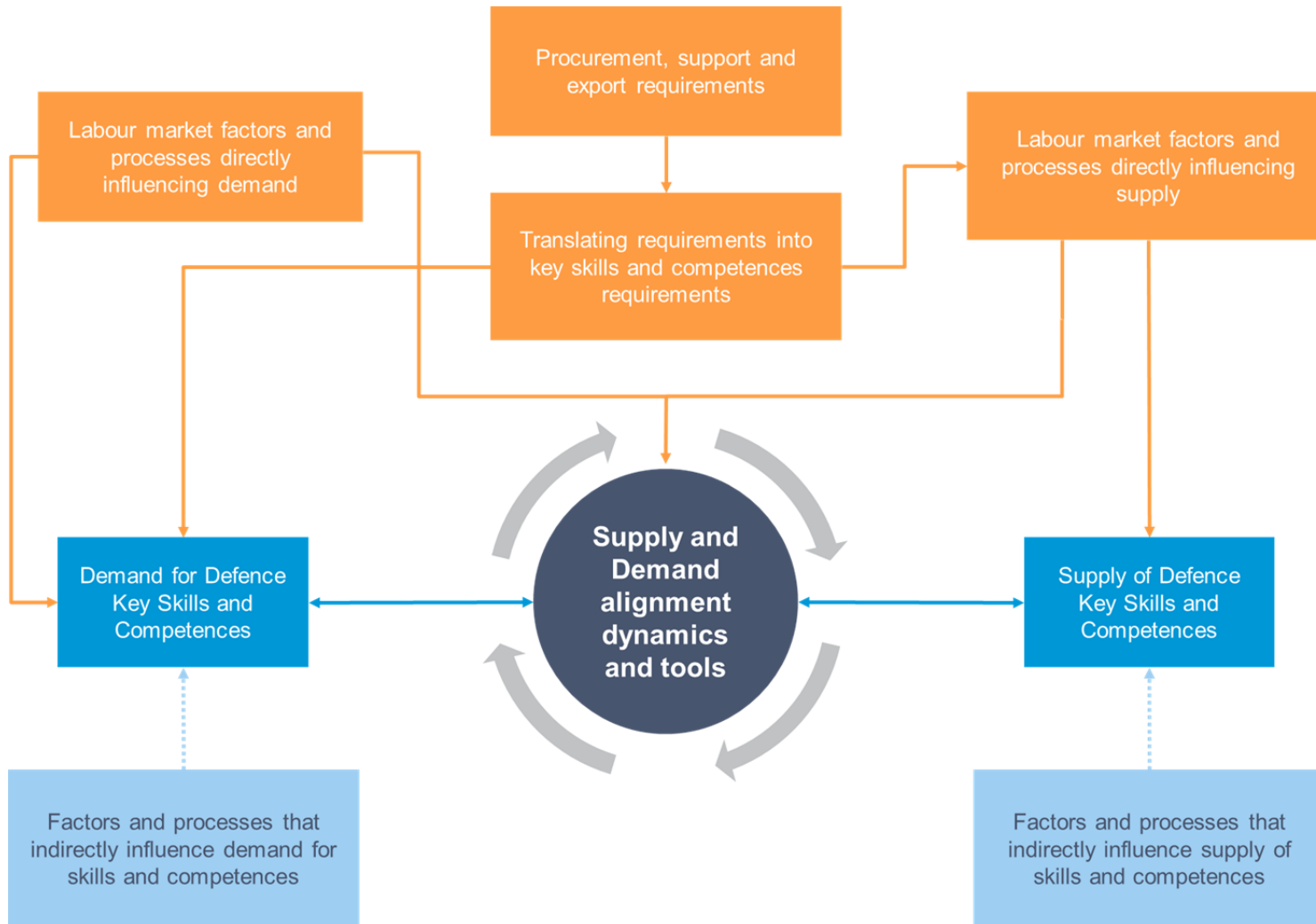
1.5. Report Outline

This report aims to understand defence-related skills availability, existing and potential skills mismatches and to map out the skills supply landscape in Europe in order to design pathways to address any identified mismatches in the next stage of the project. **Chapter 2** first explores the distinctiveness of the defence market, the changing character of defence capabilities, and emerging new technologies; and also considers what these unique **demand dynamics** mean for the ecosystem of defence-related skills. **Chapter 3** provides a more in-depth assessment of skills landscape, focusing on known **gaps and shortages of defence-related skills across Europe and explores scenarios** of the type of skills that may be required in the future. **Chapters 4** analyses the **supply of defence-related skills** by mapping and analysing existing and emerging strategies, policies and initiatives at the EU, national, regional, and company levels. Finally, **Chapter 5** articulates the general **implications of identified gaps in education and training programmes** for the ongoing development of a common vision for a European approach to defence-related skills and considers the next steps for improving skills availability, which will crystallise into recommendations and supporting actions over the course of this ongoing project as more data collection, analysis and stakeholder consultation are completed. Figure 1.2 below represents the overall structure of this report.

Figure 1.1 Report outline and methods used

Chapter	Objectives	Methods			
		Literature review	Interviews	Survey	EDSP workshop
Chapter 1 Introduction	Introduces the policy context and explains the background of defence skills in Europe Introduces the methods and presents the structure of the report	✓			
Chapter 2 Factors shaping the demand for skills in defence industry	Explains distinctiveness of the defence market, the changing character of defence capabilities, and key emerging new technologies Explores what demand dynamics mean for the ecosystem of defence skills	✓		✓	
Chapter 3 Skills needed today and tomorrow	Presents a picture of the skills currently needed in the EDTIB Identifies skills that are needed for the future, highlighting the factors that drive changes in skills needs.		✓	✓	✓
Chapter 4 Mapping of strategies, policies and initiatives on defence-related skills	Analyses the supply landscape of defence-related skills by mapping the existing and emerging policies, programmes, and initiatives on the EU, national, regional, industry, and company level	✓	✓	✓	✓
Chapter 5 Conclusions and key considerations for a sectoral skills strategy	Articulates implications of identified gaps in skills programmes for European approach to defence-related skills	Synthesis and analysis of all data sources			

Figure 1.2 General relationship map of the supply and demand of the defence industrial skills market



1.6. Approach

To build a fulsome understanding of the defence-related skills landscape in Europe, the project team have used a set of different methods, which included reviewing existing open-source literature and gathering and analysing new sources of primary data. More detail on all methods applied in this report is available in the *Methodologies Annex*.

1.6.1. Document and literature review

The project team conducted a qualitative supply and demand analysis in order to develop a better understanding of the defence-related skills landscape in Europe. Pursuing a two-tiered approach to the analysis, the team first examined the drivers and strategic requirements for defence-related skills in the grey and academic literature (e.g. policy documents, industry briefs, research reports). Secondly, information was gathered on **17 EU-level policies and funding instruments, 371 defence-related skills programmes and initiatives across 16 European Member States**²¹ that seek to develop the supply of defence-related skills. The search included a variety of types of programmes and initiatives managed by the defence industry, education institutions, or governmental bodies, and covered a broad range from structured national-level apprenticeships, to intra-company initiatives, or informal mentoring schemes. While academic publications were reviewed as part of the research, due to the dearth of academic sources, particularly in the European context, grey literature (policy documents, non-academic publications, industry briefs, etc.) and information found on company websites represent the majority of sources.

1.6.2. Survey

A **survey among defence industry representatives** complements the findings concerning the state-of-play in the area of defence-related skills gaps in Europe. The survey was designed to build an understanding of the gaps and shortages as experienced and perceived by the key players of the European defence industry, both for today and for the future. It also aimed to identify existing and potential future challenges for defence-related skills, posed by new and emerging technologies. The project team has obtained 81 survey responses, covering six domains: land, naval, air, space, cyber, and complex weapons. As a basis for the survey, the project team refined the initial defence industrial skills taxonomy developed for the 2015 project on Key Skills and Competences for Defence,²² updating this in light of industry feedback and more recent developments, for the purpose of differentiating between skills that are cross-cutting and specialised for each defence domain.

Given the granular breakdown of respondents (by domain expertise, country, company size), the limited sample size would not allow for a statistical analysis. Therefore, the survey results were triangulated with insights from literature and stakeholder input. Mindful of these limitations, the survey results were

²¹ Selected countries include: AT, BE, CZ, DE, DK, EE, ES, FI, FR, IT, LV, LT, NL, PL, SE, and UK.

²² Retter (2015).

analysed in a qualitative way, with additional data points concerning skills mismatches integrated therein based on the skills taxonomy.

1.6.3. Expert interviews

To augment the desk research and literature review, the project team conducted **51 expert interviews** with some of the key stakeholders in the defence industry and skills and employment areas across the European Member States. All interviewee data is presented in an anonymised way and is not attributed to individual interviewees. The purpose of the stakeholder interviews was to:

1. Obtain country expert and stakeholder views on existing skills initiatives and perceived skills gaps;
2. Complement, triangulate and add depth to the secondary data analysis;
3. Engage a broader network of stakeholders for enriching the proposals for supporting actions.

1.6.4. The role of the EDSP and the Steering Committee

As part of this ongoing project, an industry-led **European Defence Skills Partnership** (EDSP) has also been formed to consolidate stakeholder cooperation on skills and elicit expert input to the ongoing formulation of a sectoral skills strategy. Partnership members are working together to validate the emerging findings of this RAND-led research and the EDSP will deliver the sectoral strategy in 2019 with a series of concrete implementation roadmaps, as well as recommendations for education and training and for rolling out actions at national and regional levels, including through the ESIF. The EDSP represents a cross section of the defence skills stakeholder community from:

- European defence industry and industry associations;
- National Ministry of Defence (MOD) representatives;
- Defence innovation organisations and research institutes;
- Labour market and employment policymakers;
- Academia, specialised defence education establishments; and
- Vocational and training providers.

The EDSP members actively participated in producing this report. Specifically, three interactive workshops with EDSP were conducted in the first phase of the project, where the EDSP members provided their views and inputs on the formulation of methods and the interpretation of findings presented in this report. Given that the EDSP served an important source of triangulation, representative insights from the EDSP workshops are also reflected in this report.

An expert **Steering Committee** (SC) has also been established to support the development of the sectoral skills strategy. Comprising five independent senior experts across academia, industry and associations, the SC guides the work of the project team and provides additional expert advice. The feedback and guidance of the SC members has been taken on board in the process of finalising this report.

2. What factors shape the demand for skills in defence industry?

The need for defence-related skills does not exist in a vacuum; instead the skills are needed to deliver the types of military capability needed by European forces to protect Europe's citizens, interests and values against emerging threats. Capability is defined by NATO as 'the ability to create an effect through employment of an integrated set of aspects categorized as doctrine, organisation, training, materiel, leadership development, personnel, facilities, and interoperability' (DOTMLPF-I).²³ These skills ensure that European industry can fulfil the demand for equipment, products and services from the national armed forces of EU MS, so as to ensure operational advantage over a potential adversary and help the sustain the EU MS's deployment needs.

This chapter first explains the unique nature of the demand and supply relationship in defence and what it means for skills (Section 2.2). Section 2.3 then considers European defence spending trends and how these affect defence investment and procurement, with knock-on implications for skills in terms of the level of industrial activity required. The chapter concludes with exploring the potential impact of new and emerging technological developments on the volume and nature of skills that might be required by industry for the future (Section 2.4). This chapter focuses on the initiatives and factors of the demand side, referencing the skills relationship map (see Figure 1.2 in Chapter 1).

Box 2.1 Chapter summary: factors shaping the demand for skills in defence industry

First, the relationship between capability demand and the supply of relevant skills is influenced by the monopsony of the national market and the fragmentation of European-level demand

- The demand for and supply of defence-related skills is influenced by the effectiveness of communication between the government and the industry as to future needs
- Differences in national context shape defence capability requirements and influence budgetary planning cycles and impede industry's ability to plan for the acquisition and the skills needed in future;
- National governments, the EU and NATO have **differing approaches to defence capability planning**, making it more difficult to ensure the assortment of skills required and prioritise investments. The European Defence Fund (EDF) could help streamline EU and some of the national defence funding, supporting the development and maintenance of skills, though the vast majority of defence investment will still be allocated at the national level for the foreseeable future.
- Traditional platform-centric warfare has **shifted towards a more 'systems of systems' based approach**, driving the need for different types of skills, with a focus on dual-use technologies, interoperability of equipment, systems integration, and skills focused on the integration of new technologies.

²³ NATO. N.d. 'Translating Capability Requirements into Capability Packages'. As of 21st December 2018: http://act.nato.int/images/stories/events/2012/id/brief_solomon.pdf

Secondly, insufficient defence investment in procurement and R&D in the EU MS since early 1990s in Europe has led to reduced demand for defence design and production skills, with industry focusing instead on supporting legacy equipment often developed decades ago

- The steady decrease of defence budgets and the perception of the peace dividend in Europe since the early 1990s and until the mid-2010s, coupled with the growing focus on expeditionary operations, has reduced the overall demand for the EDTIB and has led to stagnation in some defence skills;

Thirdly, the integration of new technologies in defence capability planning will shape the nature of the required industrial skills and the challenge of integrating these into new defence products and services

- Rapid technological developments in the civil and defence sectors are acting as a **push factor**, while market-driven commercial rationale and national defence responses to a changing threat environment act as a **pull factor**
- Adoption of new technologies by the EDTIB is already affecting skills demand, while challenges in recruiting specialist skills are expected to continue in future
- New technologies may introduce a greater need for flexibility throughout the equipment life-cycle, along with changes in manufacturing supply lines

2.1. Demand for defence capabilities

This section focuses on the demand for defence capabilities, which is a key driver for the development and sustainment of skills in the defence industry. Demand for skills in the defence industry is primarily driven by the demand from the EU MS national governments for the design, manufacturing and servicing of specific defence capabilities (i.e. equipment). The decisions on the type of capabilities required by each EU MS is based on a nationally-specific defence planning process, which involves military, political and civil service actors.²⁴ Defence capability planning and development are constrained and shaped by multiple factors, such as:

- Trends in public expenditure on defence;
- Competition for finite financial, political and organisational resources in the public sector, given other government priorities (e.g. health, education, transport);
- National perceptions of the threat and security environment;
- National levels of ambition for defence, either in terms of sovereign or multilateral action;
- Existing capability levels and lifecycles for legacy equipment;
- Deployment priorities and standing commitments;
- Supporting functions requirements, such as personnel training, maintenance; and
- Equipment interoperability imperatives with other systems, enablers and international allies.

The strategic vision for the security and defence of a country is typically translated into a capability development or armaments programme. Military capability can be viewed as a system of interdependent components with defined life-cycles and is mostly used in acquisition. Other main ways of defining military capability is as an effect to execute tasks (e.g. command and control or situational awareness) and

²⁴ Larsen, Kristian and Magnus Håkenstad. 2012. 'Long-term defence planning: A comparative study of seven countries'. *Oslo Files on Defence and Security* (5). As of 24th December 2018: <https://brage.bibsys.no/xmlui/handle/11250/99805>

as the fighting power of units, measures by force structure, preparedness and sustainability.²⁵ If sufficient funds are allocated for capability procurement, the government should then carry out a market analysis and commission market players through a public procurement procedure and/or engage industry in a joint research and development effort. As a result of such a public-private partnership in defence R&D the government would benefit from the skills and expertise available in the private sector.

Defence capability development takes place in an environment of inherent uncertainty about long-term plans, which may pose challenges for the EDTIB to ensure skills are readily available for production and support of existing and new capabilities. The notice given by government about future spending priorities may be eclipsed by the long lead times involved in developing staff up to the requisite levels of expertise in many of the more niche and defence-specific technical areas needed. Technological advancement of defence equipment, coupled with the rapid proliferation of new civil and dual-use technologies also further impacts the required skills landscape, both nationally and on a European and global level.²⁶ Furthermore, the innovation 'balance of power' is shifting as civil and dual-use technologies are increasingly taken-up by the defence sector, reversing the trend that previously saw major investments in defence R&D spill-over into the civilian world through transformative military technologies such as modern computing, jet travel, the Internet, or space communications.²⁷

All these considerations shape the demand for defence capabilities which, in turn, trickles down to the industry. Catering for the national governments, exports, and often a share of civilian business, defence companies must sustain and develop relevant skills to remain competitive under the unique and challenging conditions of the market.

2.2. Monopsony of the national market and the fragmentation of European-level demand

The nature of the defence industry is characterised by the monopsony relationship between the government as a regulator and a sole customer, and multiple defence companies or, in some capability areas, an effective monopoly on the supply side (e.g. Naval Group is the only manufacturer of nuclear submarines in France, and the French Navy is its only customer for this strategic-level defence asset).²⁸ Its strategic importance to national security, sovereignty, influence and security of supply exempts the defence industry from many of the competition rules guiding market economies and, indeed, from aspects

²⁵ Anteroinen, Jukka. 2012. 'Holistic Military Capability Life Cycle Model.' *National Defence University of Finland, 2012*. As of 3 September 2018:

<https://pdfs.semanticscholar.org/presentation/163f/30efca45ff42b27d3b795241f57bab2d5ee4.pdf>

²⁶ Freeman, Jon, Tess Hellgren, Michele Mastroeni, Giacomo Persi Paoli, Kate Cox, and James Black. 2015. *Innovation models for defence*. Santa Monica, Calif.: *RAND Corporation*. RB-9808-MOD. As of September 28, 2018: https://www.rand.org/pubs/research_briefs/RB9808.html

²⁷ Ibid.

²⁸ Dunne, Paul. 2015. 'Sector Futures: Defence industry.' *Eurofound*: 23 December 2015. As of 3 September, 2018: <https://www.eurofound.europa.eu/observatories/emcc/articles/business/sector-futures-defence-industry>

of EU law.²⁹ The ultimate rationale for preserving and developing defence industrial skills stems from governments' defence capability programmes and spending cycles – with industry incentivised to sustain only those skills where there is a clear indication of demand from national MODs (and to a lesser extent from potential export customers) that future spending plans will provide sufficient work to make that skill commercially viable and to enable the learning opportunities needed to train up the next generation of employees in that area. Figure 2.1 depicts other implications of this market structure.

Figure 2.1 Implications of defence market structure on skills



Sources: RAND analysis based on Dunne (2015) and Black et al (2016).

²⁹ EU MS can invoke national sovereignty clause as part of TFEU Article 346. Source: *Lisbon Treaty.org*. 'Article 346'. As of 21st December 2018: <http://www.lisbon-treaty.org/wcm/the-lisbon-treaty/treaty-on-the-functioning-of-the-european-union-and-comments/part-7-general-and-final-provisions/589-article-346.html>

2.2.1. Communication between the government and the industry

The exchange of information on potential future procurement plans has been notoriously challenging in this sector due to the heightened classification of defence capability plans, high levels of uncertainty about the future (in political, budgetary, technological and threat terms), and variable levels of trust between national governments, industry and the private sector.³⁰ For instance, some countries, such as **Sweden, France and the Netherlands**, demonstrate a close strategic relationship between the governments and the industry, closely aligning national capability plans and skills supply strategies, which involves cooperation with academic institutions and extensive in-house training programmes. Differing results in achieving this alignment do not reflect any single factor, such as the degree of state versus private ownership of industry, with different nations using a range of different levers to promote this close collaboration according to the specific constraints of national economic and industrial policy. However, this level of alignment is not uniform across Europe.

The communication of defence equipment requirements can also prove difficult in a multinational setting such as the EU, where national capability and equipment configuration requirements vary across EU Member States. The EU has recently been actively pursuing options for better EU MS coordination of defence planning priorities and facilitation of the delivery of short, medium and long-term defence capability priorities. The EU Global Strategy sets a vision for synchronised national defence planning cycles and development approaches.³¹ Other examples of these initiatives include: updating the EDA's Capability Development Plan (CDP); establishing the Coordinated Annual Review of Defence (CARD) process, launching PESCO and the EDF.

The establishment of the European Defence Fund in 2017 is expected to lead to an inflow of financial resources into defence capability requirement funding through supporting research and development of defence equipment, with a focus on 'cutting-edge' technologies, products and services. A more detailed description of EU-level developments in support of defence industrial skills may be found in Chapter 4.

2.2.2. Differences in capability requirements influence budgetary planning cycles

Because of considerable variation between Member States in their national context, defence capability requirements will be different. Key factors that may impact the specific capability and its configuration required by national armed forces include:

- Geostrategic location;
- Terrain and climate;
- Force structures;
- Allotted tasks of the armed forces;

³⁰ Black, J. D. Jenkins, G. Persi Paoli, M. Kepe, A. Kokkoris, J. Hlavka. 2016. *Central and Eastern European countries: measures to enhance balances defence industry in Europe and to address barriers to defence cooperation across Europe*. Santa Monica, Calif.: RAND Corporation: Annex to RR-1459-EDA. As of 9 September 2018: <https://www.eda.europa.eu/docs/default-source/documents/rr-1459-eda-central-and-eastern-europe-report---technical-annex---final.pdf>

³¹ European Union External Action (EEAS). 2016. 'European Union Global Strategy'. As of 20th December 2018: https://eeas.europa.eu/archives/docs/top_stories/pdf/eugs_review_web.pdf

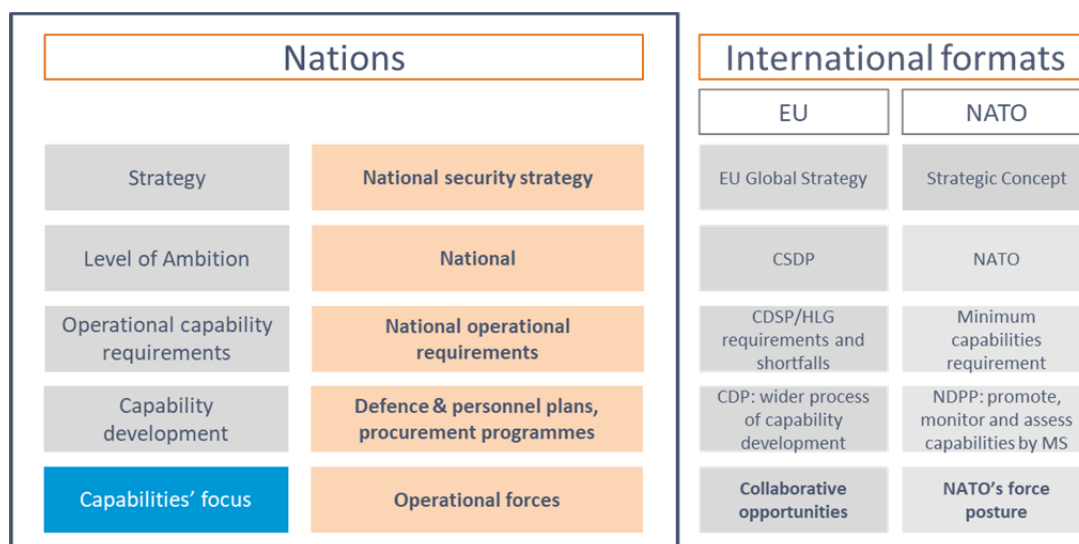
- Differences in deployment policies, and
- Idiosyncrasies of national defence capability planning approaches.

Together with the overall availability of resources and the nature of procurement and budgetary planning cycles, these factors have an impact on the type of capability a country may plan to develop or acquire (e.g. an armoured vehicle or a frigate), as well as the specific characteristics of the platform or system in question (e.g. in the case of armoured vehicles, attributes such as speed, size, weight, mobility, armour, weapons, sensors and communications).

2.2.3. Differences in national defence planning and the EU and NATO membership

The specific stages and timelines involved in defence planning processes in Europe differ significantly among the three layers of the European defence policy and posture context – national, EU, and NATO – thus making alignment of requirements more challenging. Moreover, the ultimate purpose of capabilities is understood in a different manner amongst and within these contexts due to differences in aims, mandates and processes. While nations prioritise the development and maintenance of operational forces, NATO’s efforts focus on its force posture,³² and the EU targets multinational cooperation. (see Figure 2.2). These overlapping but nonetheless often differing approaches to capability planning can make it more difficult for industrial actors in the EDTIB to have a holistic view of capability requirements and translate these into its own skills needs. However, on the EU MS level, there is scope for the European Defence Fund to have an impact on clarifying and aligning capabilities focus.

Figure 2.2 Different defence planning approaches: national governments, NATO and the EU³³



Source: RAND Europe, adapted from Cingendael (2017)³⁴

³² Force posture is broadly understood as current military capabilities, the locations and position of the forces, undertaken military actions, as well as infrastructure, development, testing and engineering, civilian and military personnel, industrial base and economic basis that insure the readiness of said military capabilities. See: Bunn, Elaine. 2004. 'Force Posture and Dissuasion'. *Strategic Insights* 3 (10). As of 22 December 2018: <https://www.comw.org/qdr/fulltext/0410bunn.pdf>

³³ NATO and EU have a different set of member states with twenty-two overlapping among the two organisations.

2.2.4. Increasing complexity of systems and cross-cutting defence lines of development dynamics

Traditional platform-centric warfare, where specific platforms or weapons (e.g. helicopters or main battle tanks) are singled out for gaining decisive advantage is being replaced by a ‘network-centric’ approach, where strategic advantage is gained through the ability to collect and share information, and coordinate the subsequent delivery of kinetic and non-kinetic effects, across a range of different systems and units.³⁵ Military equipment has also grown in technological complexity, now forming a part of a broader military system or system of systems and supported by different enablers and non-combat equipment (see Figure 2.3). It is integrated into the ecosystem of existing military doctrine, organisation and structure, training, personnel maintenance and supply practice, leaderships and command elements (DOTMLPF-I).

Figure 2.3 Example of general options for delivering a given capability

System of systems	Domain	Air	Complex weapons	C4ISTAR	Land	Maritime	Space
	System	Design approach	Design for mass	High-end design	Dual use	Off the shelf	
		Platform	Manned	Optionally manned	Fully autonomous	Remotely-piloted	
		Sub-systems	Missions systems	Powerplant & propulsion	Weapons systems	Architectures & modularity	
	Capability elements	Training	Facilities	Personnel	Material		
		Doctrine & concepts	Organisation	Leadership	Interoperability		

Source: RAND Europe

The increasing complexity and need for interoperability of systems has also changed the way of thinking about defence industrial skills, as consideration of these is generally no longer restricted to a specific platform. Instead, one must consider how these are affected by wider interoperability requirements, the dual use nature of equipment, and the impact of new technologies – with a particular emphasis on digitalisation and automation (see Section 2.4 below).

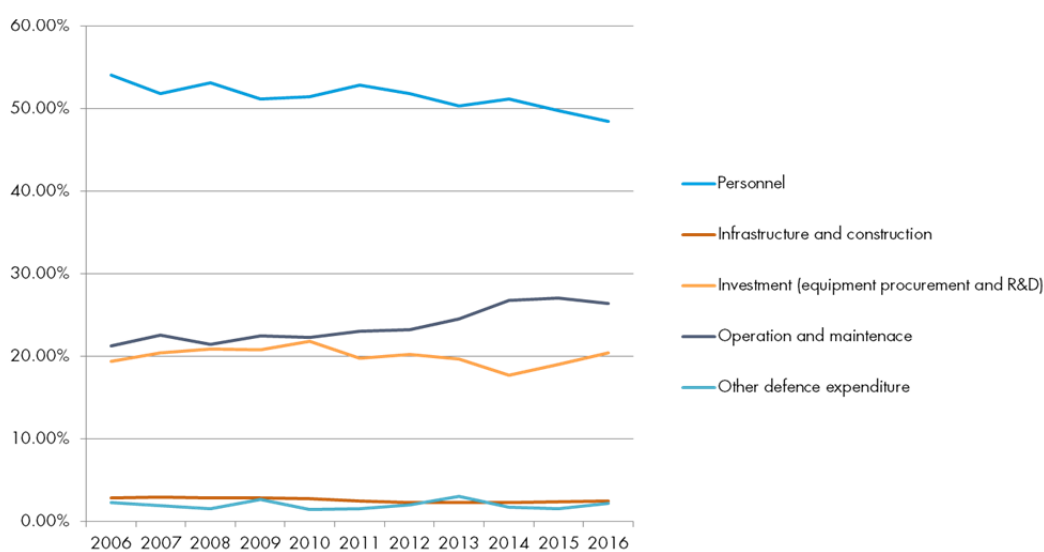
³⁴ Drent, Margriet, Eric Wilms, Dick Zandee. 2017. Making sense of European defence. *Clingendael: 2017*. As of 3 September 2018: https://www.clingendael.org/sites/default/files/2017-12/Making_Sense_of_European_Defence.pdf

³⁵ Bailey, Alvin. 2004. ‘The implications of network centric warfare.’ *US Army War College*. As of 3 September 2018: <http://ssi.armywarcollege.edu/ksil/files/00034.doc>

2.3. Legacy of scarce defence investment in procurement and R&D

Reduced budgets and disjointed investments have impacted the EDTIB's motivation for continuous production and innovation, which, is necessary to maintain existing skills and acquire new ones. Since the end of the Cold War, European defence budgets have decreased as European states focused on harnessing the perceived 'peace dividend' and down-scaling the capabilities necessary for conventional defence.³⁶ At the same time, defence and security efforts were largely focused on expeditionary humanitarian, peace-keeping, and counter-insurgency operations. Budgets for procurement of new equipment were also further hamstrung by growing personnel costs and the overall reduction in defence spending. For example, in 2006, only a few countries (France, Romania, Spain and the UK) met the 20 per cent defence investment threshold.³⁷ A similar requirement to allocate at least 20 per cent of the defence budget to the procurement of major new equipment constituted the NATO Defence Investment Pledge included in the Wales Summit declaration which recommended allocating 30 per cent to maintenance tasks and not more than 50 per cent to personnel and administration tasks. Meanwhile, the lack of collaborative multinational EU programmes and duplication of efforts across R&D, procurement and maintenance of equipment failed to generate savings, and led to inefficient use of available funding.³⁸ Although investment expenditure has increased since 2006, it is currently hovering at around 20 per cent of the national defence budgets (see Figure 2.4, noting that the figures exclude Denmark).

Figure 2.4 Defence expenditure in the EU MS (percentage shares of total defence expenditure)



Source: EDA (2017)

³⁶ (News report) The Economist. 2017. 'Military spending by NATO members'. As of 21 December 2018: <https://www.economist.com/graphic-detail/2017/02/16/military-spending-by-nato-members>

³⁷ NATO. 2017. 'Defence expenditure data of NATO countries'. As of 21 December 2018: https://www.nato.int/nato_static_fl2014/assets/pdf/pdf_2017_03/20170313_170313-pr2017-045.pdf

³⁸ RAND Europe analysis of NATO. 2017. 'Defence expenditure data of NATO countries'. As of 21st December 2018: https://www.nato.int/nato_static_fl2014/assets/pdf/pdf_2017_03/20170313_170313-pr2017-045.pdf; Eurostat. 2018. 'Government expenditure on defence.' As of 28 September 2018: https://ec.europa.eu/eurostat/statistics-explained/index.php/Government_expenditure_on_defence.

However, this picture has begun to change since late 2013, early 2014, with the decline of European defence budgets halting, and, in a number of cases, even reversing in response to changes in the wider security environment. In fact, the overall defence expenditure in Europe has doubled since 2013, due to gradual economic recovery from the 2008 financial crisis and the rise of immediate external and internal threats to Europe's defence and security.³⁹ An increased uncertainty regarding continued reliance on non-European allies for security assistance and concerns about the political cohesiveness of the EU and NATO have further encouraged investments in national capabilities.⁴⁰ Several EU MS, such as France, Germany, Poland, Sweden and the Baltic states confirmed the increase of their defence budgets, indicating that the current upward trend is likely to continue in the short to medium term.⁴¹

Recognising that an overall increase in the defence budget may not necessarily lead to an increase in spending on R&D and procurement, twenty-five of the 28 EU MS in 2017 became part of Permanent Structured Cooperation (PESCO), pledging to work towards allocating 20 per cent of their total defence spending to defence investments.⁴² Defence investment stands for expenditure for defence equipment procurement and research and development (including research and technology). The EU MS investment in defence has been increasing since 2014 and reached 2 per cent of GDP in 2017, while government investment in defence R&D specifically remains low at only 8.8 per cent of the total EU MS defence spending (excluding Denmark), remaining below the advised 2 per cent as stipulated by PESCO.⁴³

Nevertheless, across Europe, declining defence budgets and low levels of defence investment for over two decades, coupled with the inherent cyclicity of defence demand, have resulted in an overall stagnation of industrial skills and learning,⁴⁴ as well as reducing the scope for innovation and for leveraging European defence spending to build new platforms for subsequent export to third markets. However, today it may reasonably be expected that the EDTIB will ultimately benefit from increases in defence spending, if it

³⁹ Eurostat. 2018. 'Government expenditure on defence.' As of 28 September 2018: https://ec.europa.eu/eurostat/statistics-explained/index.php/Government_expenditure_on_defence

⁴⁰ (Blog post) Béraud-Sudreau, Lucie. 2018. 'European defence spending: the new consensus.' *IISS*, 15 February. As of 3 September 2018: <https://www.iiss.org/blogs/military-balance/2018/02/european-defence-spending>

⁴¹ *Ibid.*

⁴² Eurostat. 2018. 'Government expenditure on defence.' As of 28 September 2018: https://ec.europa.eu/eurostat/statistics-explained/index.php/Government_expenditure_on_defence; Council of the European Union. 2018. 'Defence cooperation: Council adopts an implementation roadmap for the Permanent Structured Cooperation (PESCO)'. As of 21 December 2018: <https://www.consilium.europa.eu/en/press/press-releases/2018/03/06/defence-cooperation-council-adopts-an-implementation-roadmap-for-the-permanent-structured-cooperation-pesco/>

⁴³ Eurostat. 2018. 'Government expenditure on defence.' As of 28 September 2018: https://ec.europa.eu/eurostat/statistics-explained/index.php/Government_expenditure_on_defence; Council of the European Union. 2017. Notification on Permanent Structured Cooperation (PESCO). As of 21 December 2018: <https://www.consilium.europa.eu/media/31511/171113-pesco-notification.pdf>

⁴⁴ Eurostat. 2018. 'Government expenditure on defence.' As of 28 September 2018: https://ec.europa.eu/eurostat/statistics-explained/index.php/Government_expenditure_on_defence; Eurostat. 2018. 'Government expenditure on defence.' As of 28 September 2018: https://ec.europa.eu/eurostat/statistics-explained/index.php/Government_expenditure_on_defence; Briani, Valerio. 2013. 'The costs of non-Europe in the defence field'. *IAI*. As of 21 December 2018: http://www.iai.it/sites/default/files/CSF-IAI_noneurope defence_april2013.pdf; RAND Europe analysis

can be translated into investment in programmes and assuming the European defence skills base has not irretrievably eroded in key areas during this lengthy recent period of low demand.

2.4. Integration of new technologies in defence capability planning

As the EU MS's capability requirements ultimately help set the stage for the technology areas to be developed within the EDTIB, corresponding skills need to be cultivated by the industry to ensure adequate supply. Increasing use of new technologies in both the defence equipment produced (i.e. the 'what') and the industrial processes for doing so (i.e. the 'how') reflects a mix of 'technology-push' as well as 'demand-pull' factors. This refers to the fact the defence sector is motivated by both the developments in the research base and civil sector, as well as by the customers' (the governments') requests for better or new capabilities to enable them to respond to new threats.⁴⁵ Technical and managerial skills, adapted to these technologies, are therefore needed not only to design and manufacture new equipment, but also to support it across the whole lifecycle (see Figure 2.5).

Figure 2.5 Defence equipment life-cycle stages



Source: RAND Europe

At the same time, considering that most defence equipment has a long life-span, that the underlying physical principles do not change, and that new technologies will have to be increasingly integrated into existing platforms, defence industry will continue to depend also on a mix of 'traditional' STEM and manufacturing skills.⁴⁶ Furthermore, while technological change has been a part of defence capability development throughout centuries, the environment in which these developments need to take place today and tomorrow may be different from those of the past centuries and decades. This is due to the trends of the future being different from those of the past, for example constantly changing labour market (e.g. changes in movement of labour and demographics) and political context (e.g. changes in levels of multinational collaboration on defence equipment programmes), while the so-called 'black swan' (e.g. unpredicted technological invention) or other events such as military conflicts may disrupt the defence industrial and labour market. This aspect constituted the inherent unpredictability of the future demand for defence capabilities as well as the supply of skills for defence industry. In addition, with an increased interest within the EU in achieving strategic autonomy and given the concerns over any potential

⁴⁵ (Blog post) Choi, Hyundo. 2017. 'Technology-push and demand-pull factors in emerging sectors: evidence from the electric vehicle market.' *Industry and Innovation*: 5 July. As of 12 September 2018: <https://www.tandfonline.com/doi/pdf/10.1080/13662716.2017.1346502?needAccess=true>

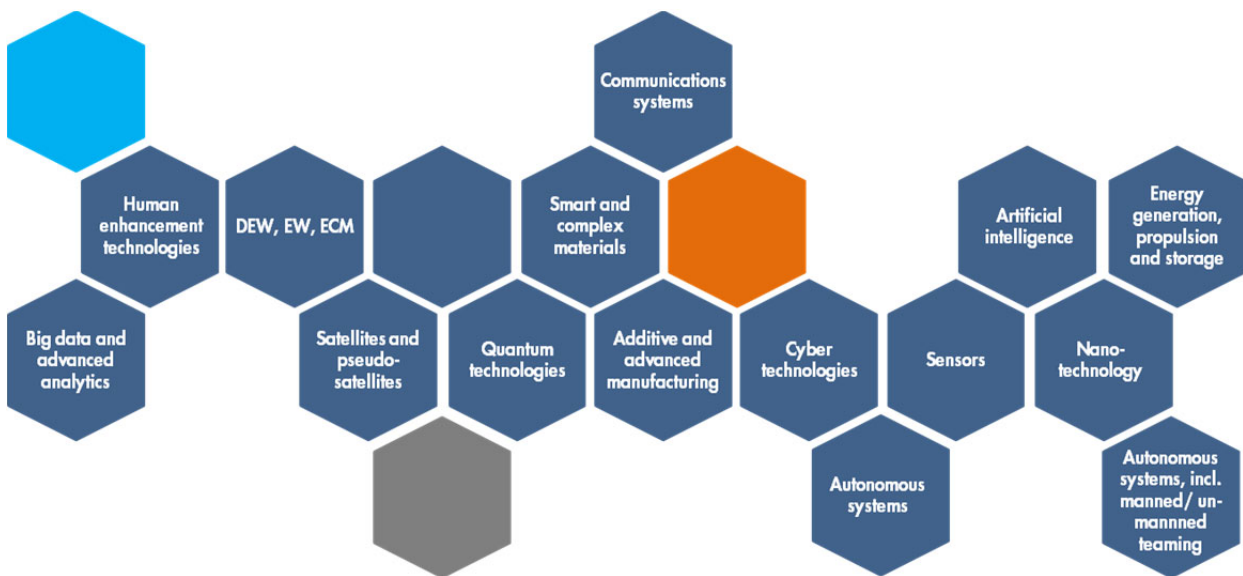
⁴⁶ Hall, Wendy, Jerome Pesenti. 'Growing the artificial intelligence industry in the UK.' 2016. As of 11 September 2018: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/652097/Growing_the_artificial_intelligence_industry_in_the_UK.pdf

weakening of the transatlantic partnership, the EDTIB will need to develop a more comprehensive set of capabilities, supported by a broader and deeper supply of skills.

2.4.1. Expanding range of new and emerging technologies

While the core existing capability areas are expected to remain relevant in future, a wide range of new technologies will increasingly be used in the defence sector. Based on a review of the defence plans of the top ten EU defence spenders, key capability areas that are expected to remain vital throughout the medium and long-term time horizons, include armoured vehicles, surface combatants and submarines, transport and fighter aircraft, intelligence, surveillance and reconnaissance (ISR) and command, control, coordination and communications (C4) capabilities. This implies a continuous need for more traditional skills needed throughout the defence equipment life-cycle, such as mechanics and electronics.⁴⁷ However, both now and in the future, the accelerating pace of technological change, potential disruptive innovation, and the introduction of emerging technologies in high impact areas (e.g. cyber, autonomy, AI, quantum technologies and hypersonics), coupled with an inherently uncertain strategic and operational environment, are likely to have a transformative impact on capability planning and, in turn, will adjust the demand for skills. Figure 2.6 presents a range of new technologies that are already being introduced into defence and manufacturing processes, or are expected to be present by 2035+.

Figure 2.6 Selected examples of emerging technology areas that may impact skills requirements in the defence industry to 2035+



Source: Adapted from Kepe et al (2018)⁴⁸

⁴⁷ Ministère des Armées. 2013. 'White Paper on Defence and National Security 2013.' As of 9 September 2018: <https://www.defense.gouv.fr/english/dgris/defence-policy/white-paper-2013/white-paper-2013>

⁴⁸ Kepe, Marta, James Black, Jack Melling, Jessica Plumridge. 2018. *Exploring Europe's capability requirements and beyond*. Santa Monica, Calif.: RAND Corporation. EP-67656. As of 10 September 2018: https://www.rand.org/pubs/external_publications/EP67656.html

The new and emerging technology landscape provides a wide menu of technologies, some of which are already being integrated into the defence sector. As a result, both the industry and skills suppliers are prompted to incorporate updated training and education of relevant technical, engineering and management skills into their respective programmes.

2.4.2. Adoption of new technologies by the EDTIB

Increased use of new technologies may pivot the skills demand towards the higher-skilled employees in a number of areas, whilst also de-skilling or automating many of the manual tasks previously conducted by 'blue collar' workers. Technology changes are expected to have profound implications for industrial design and manufacturing processes, defence products, and the strength and competitiveness of the EDTIB.⁴⁹ Although much of the innovation in new technologies is expected to be dual-use, presenting opportunities for skills transfer from the civilian to the defence sector, continued competition for the same skills with civilian industry and global competitors, negative perception of the defence industrial sector along with demographic challenges in the EU may exacerbate any challenges in skills supply.⁵⁰ The industry has already reported challenges in sourcing the skills for many of the new technologies that it currently employs and plans to employ. For example, European defence companies reported challenges in attracting employees with skills relevant to AI, while big data analytics, (fundamental to AI), is an area with one of the largest existing skills gaps.⁵¹ Other challenges include recruiting for skills relevant sensors and connectivity, advanced manufacturing, augmented and virtual reality, human machine interfaces, advanced energy generation, storage and distribution, advanced and smart materials, robotics, and unmanned systems. In the future, the industry may struggle to source skills in areas that require specialised software skills, such as advanced manufacturing, closely followed by AI and machine learning, embedded sensors and connectivity as well as advanced/smart materials.⁵²

As the above technologies become more integrated into defence equipment design and manufacturing, it may be expected that there will be an increased demand for manufacturing-related software engineers, automated systems engineers, manufacturing process engineers and supply chain engineers with skills that include **data science, AI expertise, robotics, deep learning skills and knowledge of advanced analytics as well as biotechnology, nanotechnology and pharmaceutical knowledge.**⁵³ Overall, it may be expected that defence-specific project management skills and STEM skills, especially system of systems engineering, will continue to remain important and potentially even increase in importance due to an increase in the

⁴⁹ Robinson, Neil, Agnieszka Walczak, Sophie-Charlotte Brune, Alain Esterle, and Pablo Rodriguez. 2013. *Stocktaking study of military cyber defence capabilities in the European Union (milCyberCAP): Unclassified Summary*, Santa Monica, Calif.: RAND Corporation, RR-286-EDA. As of September 22, 2018: https://www.rand.org/pubs/research_reports/RR286.html

⁵⁰ Retter, Lucia, Louise Taggart, and Jon Freeman. 2015. *Key Skills and Competences for Defence: Annex E*, European Defence Agency, RR-1226-EDA. As of September 26, 2018: https://www.rand.org/pubs/research_reports/RR1226.html

⁵¹ Nesta. 2015. 'Analytic Britain: Securing the right skills for the data-driven economy'. As of 27 September 2018: https://media.nesta.org.uk/documents/analytic_britain.pdf

⁵² RAND Europe survey (2018)

⁵³ (Blog post) Guinn, Justin. (N.d.) 'Manufacturers are hiring again; what skills are they looking for?' *Software Advice*. As of 27 September 2018: <https://www.softwareadvice.com/resources/manufacturers-skills-in-demand/>

complexity of defence equipment.⁵⁴ Multidisciplinary skills that allow working on different systems and sub-systems as well as across different types of skills will also grow in importance, thus leading to an increased need for skills such as mechatronics.

While the impact of new technologies on total employment levels is uncertain, there may be job losses within some occupations, specifically ones that are concerned with more manual tasks that could be more readily automated or else rendered unnecessary due to improvements in design and process.⁵⁵ However, the overall impact on the retention of defence-specific skills is less clear, as up-take of new technologies may also create jobs that require higher or specialised training. At the same time, considering that multiple capabilities that are being produced for the EU MS today will continue to be in demand for decades to come, some elements of traditional manufacturing and production technical/vocational skills will continue to be required.⁵⁶

2.4.3. Greater need for flexibility throughout the equipment life-cycle and changes in manufacturing supply lines

Advanced technologies, such as 3D modelling and printing, ICT, robotics and augmented reality may not only change how defence equipment is designed and manufactured, but also how it is maintained, repaired and overhauled (MRO). One industry source claims that this is expected to contribute to the performance, safety and reliability of the equipment, the efficiency and optimisation of resources, and the exploitation of new investment sources.⁵⁷ For example, unmanned aerial vehicles are already used in the marine industry to inspect hulls, thus saving time, personnel and financial resources that would otherwise be required to carry out a close-up survey of the vessel.⁵⁸

The speed at which new products are designed, introduced, maintained and/or replaced may also increase, while the maintenance and repair of these increasingly complex technologies will require higher levels of flexibility. This may lead to a need for a change in the relationship between MODs and industry, and between big prime-contractors and their supply chains, and the consequent requirement for more agile contracting and contract management skills, programme support, cost modelling and management skills to support the novel equipment through its full lifecycle.

⁵⁴ (Blog post) Adams, Jim. 2017. 'Can the aerospace & defence industry surmount its workforce issues?' *PwC*, 19 September 2017. As of 11 September 2018: <http://usblogs.pwc.com/industrialinsights/2017/09/19/can-the-aerospace-defense-industry-surmount-its-workforce-issues/>

⁵⁵ CEDEFOP. 2018a. 'Developments in vocational education and training policy in 2015-17: Poland.' *Cedefop monitoring and analysis of VET policies*. As of 5 September 2018: http://www.cedefop.europa.eu/files/poland_-_vet_policy_developments.pdf; Benedikt Frey, Carl and Michael A. Osborne. 2013. 'The Future of Employment: How Susceptible are jobs to computerisation?' *University of Oxford*. As of 21st December 2018: https://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf

⁵⁶ Hall, Wendy, Jerome Pesenti. 'Growing the artificial intelligence industry in the UK.' 2016. As of 11 September 2018:

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/652097/Growing_the_artificial_intelligence_industry_in_the_UK.pdf

⁵⁷ (Blog post) Industry Today. 2017. 'Digital technology innovations converge to transform MRO.' 14 April. As of 27 September 2018: <https://industrytoday.com/article/digital-technology-innovations-converge-transform-mro/>

⁵⁸ European Commission. 2015. 'MINOES – Result in Brief.' 15 October 2015. As of 11 September 2018: https://cordis.europa.eu/result/rcn/90677_en.html

Digitalisation leading to significant changes in the skills required by the EDTIB

Digitalisation, i.e. the increase in the use of digital technology,⁵⁹ is progressively transforming many firms in the EDTIB's internal processes, increasing the breadth and depth of skills in areas that include engineering, manufacturing, digital, space and electronics. Related to the fourth industrial revolution (Industry 4.0), digitalisation is characterised by the use of cyber-physical systems (CPS) across all stages of equipment life-cycle. While many of the required skills are not exclusive to defence and may be transferrable between different defence domains as well as between civilian and defence fields, provided relevant field-specific training is available, skills gaps are already expected in such areas as communications systems engineering, satellite communications specialists, network infrastructure, and data and information engineers.⁶⁰ Digitalisation will also increase the requirement for skills related to programming and coding in statistical packages and software design and cybersecurity skills (both to secure the actual products themselves and to protect industry networks across the supply chain against cyberattack, especially as data sharing becomes ever more sophisticated).⁶¹ A digital transformation in the EDTIB may also have adverse effects, such as increasing number of cyber espionage or disruption attempts, which may lead to a heightened demand for cyber security skills in order to protect firms as well as their products.⁶²

Industry 4.0 may also lead to a need to nurture the so-called 'soft-skills' among the already existing and future employees in the defence and other sectors. Rapid exchange of information and the use of multiple communication, management and production systems will require the European defence industry to be increasingly adaptive regarding its processes, and its employees more agile in their thinking and learning and nurture their innovative thinking, interpersonal and communication skills an ability to manage complex problems. In sum, emerging and new technologies can have an impact on defence industrial skills demand today and into the future:

Automation of manufacturing processes requiring additional skills

Automation refers to the replacement of (human) labour input by machine input for some types of tasks within production and distribution processes.⁶³ Automation may lead to a displacement or decrease in some less skilled jobs, while increasing the demand for people with the specific vocational or higher

⁵⁹ Peruffo, Eleonora; Ricardo Rodriguez Contreras, Daniel Molinuevo, Lea Schmidlechner. 2017. 'Digitisation of processes literature review'. *Eurofound*. As of 21 December 2018: <https://euagenda.eu/upload/publications/untitled-150329-ea.pdf>

⁶⁰ Retter, Lucia, Louise Taggart, and Jon Freeman. 2015. *Key Skills and Competences for Defence: Annex E*, European Defence Agency, RR-1226-EDA. As of September 26, 2018: https://www.rand.org/pubs/research_reports/RR1226.html

⁶¹ Atkins, Ella M. 2014. 'Education in the crosscutting sciences of aerospace and computing'. *Journal of Aerospace Information Systems*, 11 (10). As of 21 September 2018: <https://deepblue.lib.umich.edu/bitstream/handle/2027.42/14064/1.i010193.pdf?sequence=1&isAllowed=y>

⁶² Department of Defense (DoD). 2018. 'Fiscal Year 2017: Annual Industrial Capabilities'. As of 23rd October 2018: <https://www.businessdefense.gov/Portals/51/Documents/Resources/2017%20AIC%20RTC%2005-17-2018%20-%20Public%20Release.pdf?ver=2018-05-17-224631-340>

⁶³ Peruffo, Eleonora; Ricardo Rodriguez Contreras, Daniel Molinuevo, Lea Schmidlechner. 2017. 'Digitisation of processes literature review'. *Eurofound*. As of 21 December 2018: <https://euagenda.eu/upload/publications/untitled-150329-ea.pdf>

education training to design, support and supervise automated manufacturing technologies.⁶⁴ Automation will also require information assurance and security skills.⁶⁵ This process may drive the demand for skills relating to sensor fusion, electronics, cyber skills, big data and advanced analytics skills, programming, modelling, simulation and analysis skills, in addition to physics and mathematics. Increased use of advanced data sharing will require further sophistication of cybersecurity technologies to protect the confidentiality, integrity and availability of information and networks, as well as presenting new challenges for engineering, specific to autonomous systems and unmanned platforms.⁶⁶ Similarly to automation, this area may be subject to an increased demand for data processing and security skills.⁶⁷

Bioengineering and pharmaceutical knowledge

Media reports suggest that the defence industry is increasingly preoccupied with human enhancement technologies that, for example, augment cognition under stress, allow soldiers to better cope with fatigue and exertion, and support weight-bearing abilities.⁶⁸ Human-enhancement technologies will require highly skilled personnel and educational and training programmes in areas such as biomedical engineering, electrical engineering, nanotechnology, health sciences, and pharmacology that not only provide the specialised education for research and design but also allow maintaining and constantly updating it.⁶⁹ Staff with relevant legal and ethics knowledge will also be required due to the ethical and legal complexities relating to research, manufacturing and the use of human-enhancement technologies.

The demand for multidisciplinary skills

Due to growth in the complexity of defence systems and systems of systems, the demand for multidisciplinary skills is also likely to increase. Skills that allow working on the interoperability of different systems and the interaction of systems in operating in different domains (e.g. land, sea, air, space, cyber) will be required not only in the design, manufacturing, production and maintenance phases of an equipment lifecycle, but also on the management and contracting level.

⁶⁴ (Blog post) McKinsey. 2018. 'How will automation affect jobs, skills, and wages?' March. As of 12 September 2018: <https://www.mckinsey.com/featured-insights/future-of-organizations-and-work/how-will-automation-affect-jobs-skills-and-wages>

⁶⁵ Retter (2015).

⁶⁶ Robinson, Neil, Agnieszka Walczak, Sophie-Charlotte Brune, Alain Esterle, and Pablo Rodriguez. 2013. *Stocktaking study of military cyber defence capabilities in the European Union (milCyberCAP): Unclassified Summary*, Santa Monica, Calif.: RAND Corporation, RR-286-EDA. As of 22 September 2018: https://www.rand.org/pubs/research_reports/RR286.html

⁶⁷ Retter (2015).

⁶⁸ (Blog post) Tucker, Patrick. 2017. 'Tomorrow Soldier: how the military is altering the limits of human performance.' *Defense One*: 12 July. As of 11 September 2018: <https://www.defenseone.com/technology/2017/07/tomorrow-soldier-how-military-altering-limits-human-performance/139374/>

⁶⁹ (Blog post) Monaco, Ania. 2012. 'What it takes to be a bioengineer.' *The Institute*: 7 December. As of 11 September 2018: <http://theinstitute.ieee.org/career-and-education/career-guidance/what-it-takes-to-be-a-bioengineer>

2.5. Conclusion

To sum up, the demand for defence industrial skills is ultimately driven by the strategic capability demand capabilities set out by national governments. Whether produced in-house or acquired off-the-shelf, procurement, design, manufacturing, in-service support, management and disposal of the defence equipment directly formulate the requirement for necessary skills.

The relationship between defence capability demand and skills needs is further conditioned by the unique nature of the market with its long planning and development cycles, limited R&D funding, monopsony of the national market and the fragmentation of European-level demand. Furthermore, potential future increase in the EU governments' demand for new technologies, coupled with a rapid technological developments in the civil and defence sectors are acting as a push factor; while market-driven commercial rationale and national defence responses to a changing threat environment act as a pull factor.

Having provided the context for what constitutes demand for defence industrial skills and what factors may influence it, the next chapter considers in more depth specific skills shortages and gaps in the EDTIB.

3. What skills are required by the EDTIB and are difficult to source?

This chapter presents a picture of the skills currently needed in the EDTIB, identifies skills that are needed for the future and highlights the factors that drive changes in skills needs. Drawing on the analysis of the online survey data (see Annex A for detail), stakeholder and expert engagement, and desk research, this chapter also highlights skills gaps and shortages, and provides explanations of factors that hinder the availability of skills for the EDTIB.

Any statements not specifically referenced in this chapter reflect the findings of RAND Europe stakeholder engagement (expert interviews and workshops with EDSP members). Insights obtained during the interviews are integrated throughout the report and the interview protocol can be found in Methodologies Annex.

Box 3.1 Chapter summary: What skills are required by the EDTIB and are difficult to source?

Availability and access to the right skills are critical for a competitive and vibrant EU defence industrial base to deliver defence capability

Given that the demand for skills is mainly driven by defence equipment programmes and new and emerging technologies, skills needed in the EU defence industrial base now and in the future are:

- Skills that enable the delivery of current and planned defence equipment programmes
- Skills that enable the industrial base to harness technological advances and remain innovative and competitive (some of the key skills areas here include digital skills, data analytics, software design and engineering, autonomy and automation related skills and cyber skills)
- There is an overlap between current and near term skills mismatches, indicating a potential chronic difficulty in sourcing and retaining skills

There may be different reasons for the existence of skills mismatches and a number of potential implications for the EDTIB

- For skills that are more easily transferable from the civil sector, wage competition and, for some, the lower attractiveness of defence are seen to drive mismatches
- For domain specific skills, low defence demand and demographic challenges are seen as key drivers of skills mismatches due to the high risk of skills atrophy in the absence of new capability programmes
- Skills mismatches can have a profound impact on the EDTIB, potentially undermining companies' competitiveness and ability to innovate

Uncertainty in relation to defence demand and competition for talent further affect industries' ability to actively manage their skills base

- Increasing competition in the defence market has created more uncertainty for EU defence industry and the need to take commercial risk when deciding to retain or develop skills
- For SMEs, competition for talent is a key concern, while larger companies report skills challenges due to insufficient defence demand

3.1. Introduction to defence industrial skills demand

A wide range of defence equipment programmes are currently ongoing or planned within EU Member States, including both national and collaborative programmes involving two or more nations. Depending on what the requirement is (e.g. is the MOD intending to design and develop a new national design solution to maritime patrol aircraft requirements, or does it want to procure a dozen armoured personnel carriers off-the-shelf with logistics support and maintenance?), different skills will be required to deliver the equipment or service.

Technology will also continue to shape both the volume and nature of skills and will drive changes in skills needs across the EDTIB. For example, embedding automated, data-enhanced systems within defence companies with a strong manufacturing component may facilitate faster, more accurate and cost-efficient production processes, helping companies become more competitive. At the same time, they would likely reduce the need for manual shop floor work but would increase the need for digital skills such as data analytics, software engineering as well as cyber security skills to protect data generation, transfer and storage.

Skills and competences of the workforce employed by companies that provide support to governments and national militaries responsible for delivering defence capability underpin the strength of any defence industrial base. The volume and quality of skills embedded in the workforce represent one of the main indicators of a healthy industrial base. Other indicators of health of an industrial base include, for example: R&D investment, supply chain resilience, capital investment, exports and others. Skills are needed to develop, design, manufacture and maintain defence equipment such as helicopters and frigates and to deliver services such as upgrading software and delivering maintenance. Depending on the type of equipment and the type of services, different skills are required. Most often, skills required by defence industry workforce to deliver defence programmes include a combination of:

- **General technical skills:** these are skills held by people with a secondary or tertiary education level degree in STEM subjects, with varying levels of expertise and different levels of uniqueness to defence. Examples include: mechanical engineering, whole systems engineering, design validation as well as skills used in manufacturing, with unique to defence skills including low observability design, engineering and manufacturing, mission systems engineering, mission design and others. In this report, these are also referred to as ‘cross-cutting defence skills’ as they cut across multiple defence domains (including air, land, naval, C4ISTAR, complex weapons and space);
- **Skills specific to a particular defence domain:** these are technical skills with a narrow application in a specific domain, for example ballistics engineering in the land domain, aerodynamics in the air domain, specialist manufacturing skills and others;
- **Programme and project management skills** including cost estimation, ability to navigate regulations and rules such as export controls, procurement regulations, planning and production support and others;
- **Skills embedded in supporting functions** such as general legal, human resources, IT support and others;

- **Enabling skills** or ‘soft’ skills such as critical thinking, leadership, communication skills, language skills and others.

The focus of this chapter is on skills that are more likely to be specific to defence or at least require a specific technical training to adapt to the defence context. While staff in **support functions such as contracting and legal counsel** will require knowledge and understanding of the defence context to operate effectively (for example in relation to the export controls and other defence-specific regulations), their underlying legal and commercial skills will remain the foundation. Similarly, just like any other industrial sector, the EDTIB needs enabling skills such as **critical thinking, resilience and leadership** to operate effectively but the development of these is not unique to the defence context. Figure 3.1 provides an aggregate skills demand overview for 10 selected EU MS, based on the analysis of interview outputs, survey results, secondary data, and EDSP inputs.

To capture the full range of technical and project management skills that may be required, as well as soft skills, the research team developed taxonomy of defence skills (see *Methodologies Annex C*). It captures skills that cut across multiple defence domains, enhanced by skills that are specific to individual domains (e.g. air, land, naval). In addition, the taxonomy captures so called ‘soft skills’ which are not job-specific but relate to personal competences such as confidence, discipline, self-management and social competences such as teamwork, communication and emotional intelligence.⁷⁰ Examples include: customer-handling, communication, teamwork, critical thinking, problem solving and others.

Finally, defence industry also requires skills that will enable it to successfully harness technological innovation. Skills particularly needed in the future might relate to **artificial intelligence and machine learning, sensors, advanced manufacturing, augmented and virtual reality and robotics**, with interviewees noting the rising need for **cyber skills**. Survey respondents also anticipate a growth in the need for skills in **quantum technologies, nanotechnologies, biotechnologies and synthetic biology**.⁷¹

Skills shortages, refer to a ‘situation in the labour market where the demand for particular type of skills is higher than the supply of workers with that type of skill’ (Skills Panorama)
















Skills gaps, refer to a ‘situation where the type of skills of people do not match the requirements of the job or the level of skills is less than the level required to perform the tasks associated with the job satisfactorily.’ (Skills Panorama)

Skills mismatches, refers to a ‘situation of imbalance in which the level or type of skills available does not correspond to labour market needs.’(CEDEFOP)

⁷⁰ Skills Panorama 2018c. ‘Soft Skills.’ As of 12 November:
<https://skillspanorama.cedefop.europa.eu/en/content/soft-skills>

⁷¹ RAND Survey of industry and other defence organisations, September 2018.

Figure 3.1 Overview of skills demand landscape in selected 10 EU MS, split by domain and highlighting identified skills gaps and shortages

Country	DTIB size			Skills demand						Defence capabilities	Identified skills gaps and shortages
	Turnover Bn € p/a	Employees	Main companies								
 Denmark	0.4B	3,000	Terma, Scandinavian Avionics, Systematic, Gomspace, Hydrema	✓			✓			Manufactures subcomponents and parts of weapon systems	Production planning, administrative and management, quality control , advanced manufacturing, electronics, and software engineering
 Finland	1.4B	6,100	Patria, Sako, Bittium	✓	✓			✓		Manufactures SALW, communications solutions	Operational and technical skills: engineering, cyber security and emerging technologies, maintenance engineering and technicians
 France	15B	200,000	Airbus, Dassault Aviation, Nexter, Naval Group, MBDA, Thales, Safran	✓	✓	✓	✓	✓	✓	Manufactures aircraft, helicopters; submarines, naval vessels, weapons & missiles, space launch vehicles	Engineering, digitalisation , data management, software engineering , cyber and AI, operators and technicians
 Germany	30B	100,000	Hensoldt, Airbus, Rheinmetall, KMW, ThyssenKrupp, Lürssen	✓	✓	✓		✓		Air defence systems: TLVS(2015), NNbS(2018); ground defence: LAND 400, naval, cyber programmes	Supply chain software design and engineering , information architecture, mission management and concept design, safety, advanced automation, digitalisation
 Italy	16B	60,000	Leonardo, Fincantieri, Avio Aero, Breda, Iveco Defense Vehicles	✓		✓		✓		Naval assets MBT, armoured land vehicles, C4ISTAR, avionics, optoelectronics, radar and sensors; helicopters, UAVs	Shortage of STEM graduate to support Industry 4.0 requirements, autonomy and unmanned system engineering , weapons design, electronic warfare and material engineering
 Netherlands	4.5B	24,800	Damen, ThalesND, Fox-IT	Domain-agnostic sub-systems and components						ICT, sensors, software, simulations, electronics, containers, propulsion systems, missiles, weapons	Engineers with specialisms in mission systems, systems testing, advanced materials, synthetic environments, technicians , AI and autonomy engineering , radar systems, software engineering .
 Poland	1B	60,000	PGZ, Sikorsky/PZL Mielec, PZL-Swidnik, Shipyard Gdansk, TELDAT, Ultratech	✓			✓	✓		Armoured vehicles, electronics, air defence systems, multipurpose helicopters, UAVs, naval and surface vessels, submarines	Information architecture, autonomy engineering , mechanical and thermal engineering, systems test engineering , electrical and control engineering. Project managers, safety, strategy building
 Spain	5.7B	210,000	Navantia, Indra, Airbus, General Dynamics European Land Systems	✓		✓				Manufactures aircraft, ships, ammunition and weapons; imports armoured vehicles	Cybersecurity skills shortages (e.g. in IT design), software engineering
 Sweden	2.9B	63,000	Saab AB, BAE Systems AB, Volvo Defense AB, Kockums AB	✓	✓	✓				Combat air (Gripen); ELINT/SIGINT/AWACs aircraft; corvettes, conventional submarines; ground vehicles	Mechanical, electro-optics, automation, control systems, radars, safety, arms integration, software engineering , technicians , commercial and configuration, logistics, digitalisation
 UK	25.6B	265,000	BAE Systems, Rolls Royce, GKN, QinetiQ, Babcock, Cobham, MBDA	✓		✓			✓	Aerospace, nuclear submarines, cyber, armoured vehicles, attack and transport helicopters, satellites	Advanced manufacturing, nanotechnology and quantum science, systems and software engineering , mechanical engineering and project management

Military domains key:  Air  Cyber & C4ISR  Naval  Complex weapons  Land  Space

3.2. Skills mismatches and difficulty in sourcing the right skills

3.2.1. Skills mismatches

Through literature review, interviews with stakeholders and a detailed online survey of defence companies and other organisations active in defence, the project team has identified a number of skills mismatches. The survey responses were provided by 81 respondent organisations from 17 countries. The detailed analysis of the survey results is included in the Annex A.

For technical defence skills that are needed across different defence domains (i.e. cross-cutting defence skills), the survey evidence shows a high occurrence of external skills shortages, indicating difficulty to source the right skills from the wider labour market. In total, 72% of respondents (58 out of 81) identified skills **mismatches in technical defence skills**. Skills mismatches were also discussed within the realm of stakeholder interviews and were researched extensively during the generation of country profiles. All this information was compiled and analysed to provide as nuanced and comprehensive a picture as possible within the constraints of the sample populations of respondents and specific country profiles.

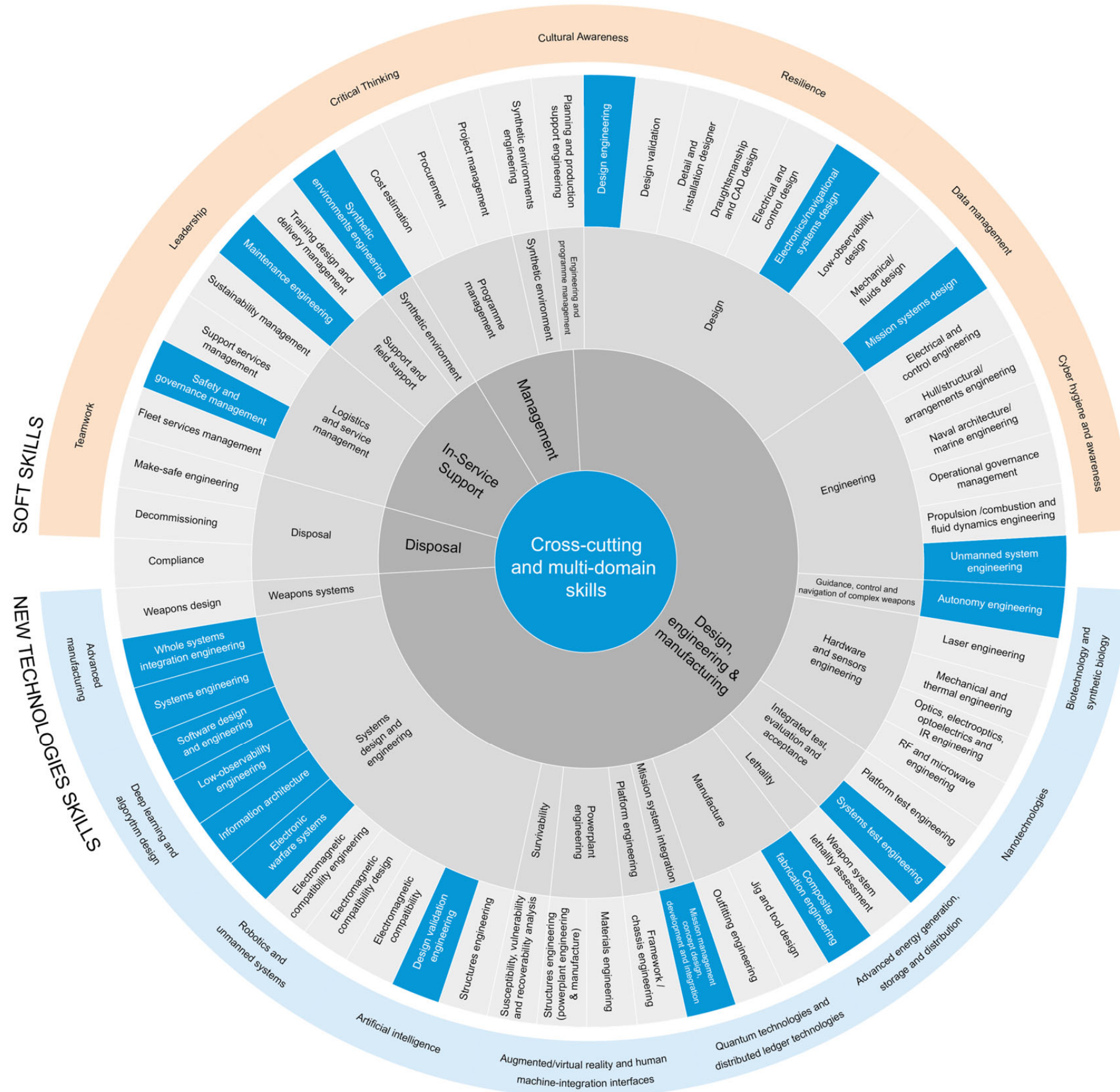
Error! Reference source not found. provides a visual summary of both the range of skills that, to a lesser or greater extent, are required today and will be required in the future within the EU defence industrial base and the mismatches that have been identified through survey, interviews and literature review (these are highlighted in blue). The highlighted skills mismatches are those that were most frequently reported in the survey as well as identified through interviews and literature review in order to triangulate the information sources.

Identified technical skills mismatches include:

autonomy engineering; composite fabrication engineering; design engineering; design validation engineering; electronic/navigational systems design; electronic warfare systems; information architecture; low-observability engineering; maintenance engineering; mission management concept design, development and integration; mission systems design; safety and governance management; software design and engineering; synthetic environments engineering; systems engineering; systems test engineering; unmanned systems engineering; whole systems integration engineering.

The precise combination of required skills will depend on the capability programme in question, which will also determine which domain specific skills are required.

Figure 3.2 A visual summary of technical defence skills needed today



Source: Adapted from RAND Europe analysis of Retter et al. (2015)

Note: The inner circle represents stages of defence equipment lifecycle (management, design engineering, manufacture, in-service support and disposal). Lighter grey circle represents skills groups, with off-white outer circle representing individual skills. Light orange semi-circle at the top represents 'soft skills' which underpin and enhance the technical skills in grey. Very light blue semi-circle at the bottom represents technology areas which will require new skills to effectively harness their potential within the defence capability development context. Highlighted in bright blue are skills mismatches as identified by survey respondents, interviewees and through literature review. For a detailed analysis of the survey data, please see Annex A.

In addition to the technical skills, further skills mismatches were also reported in relation to management and support skills. About half of the respondents to the survey questions reported particular challenges in sourcing these skills in a timely manner to meet the demands of ongoing and future defence programmes. Complementing the survey data with literature and interviews, the following specific areas have emerged as most pressing in relation to skills mismatches:

- **Marketing, business development and sales competences** that enable companies to operate in the defence market, including contacts and networking with governmental institutions and business associations at home and in potential export markets;⁷²
- **Administrative skills** and the capacity to **manage export licenses and navigate the defence regulatory systems** and other administrative procedures relating to the sale of defence equipment;
- **Project management** with specialisms in defence-related international projects, **commercial and configuration, logistics, digitalisation, procurement, operations and technology transfer**;
- **Defence economics, cost estimation, and quality control.**

A previous RAND study in 2016 documented the need for these skills particularly in the Central and Eastern European countries following the fall of the Warsaw Pact and major restructuring of the associated defence sectors.⁷³ The combination of mismatches in technical defence skills, project management and also soft skills means that some companies currently struggle to deliver equipment programmes in the most efficient way. For the future, skills mismatches could therefore undermine companies' ability to develop intellectual property to enable them to participate in domestic programmes and to export. It could also affect the value-for-money that government customers derive from these programmes, by increasing cost, schedule and performance risk and thus affecting the overall affordability of new European defence equipment.

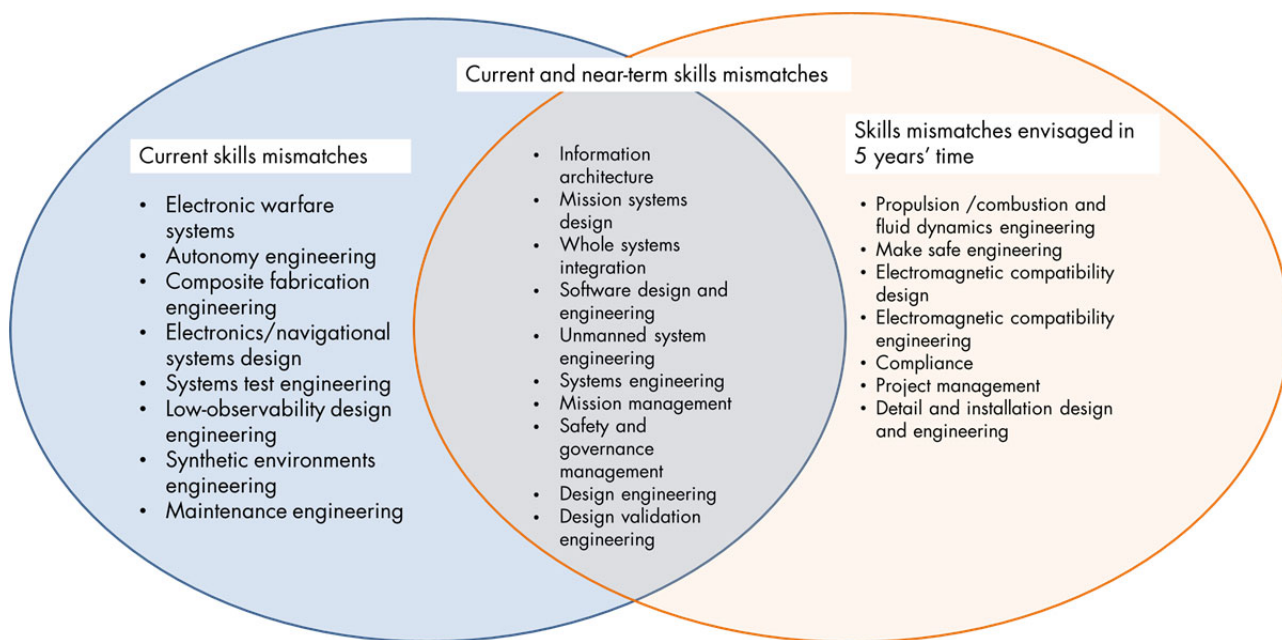
3.2.2. Potential difficulty in sourcing and retaining skills

Available data shows a strong overlap between current and near-term skills mismatches (see Figure 3.3), indicating there may be a potential chronic difficulty in sourcing and retaining relevant skills. In other words, there may be systemic reasons for the persistent skills mismatches that defy a simple or quick fix. Part of the reason for the persistency in skills mismatches could relate to the increasing involvement of European defence industries across the whole lifecycle of the equipment as well as for providing additional support (e.g. training, simulation, logistics) and as such, requiring skills at any point in time.

⁷² Black, J. D. Jenkins, G. Persi Paoli, M. Kepe, A. Kokkoris, J. Hlavka. 2016. *Central and Eastern European countries: measures to enhance balances defence industry in Europe and to address barriers to defence cooperation across Europe*. Santa Monica, Calif.: RAND Corporation: Annex to RR-1459-EDA. As of 9 September 2018: <https://www.eda.europa.eu/docs/default-source/documents/rr-1459-eda-central-and-eastern-europe-report---technical-annex---final.pdf>

⁷³ Ibid.

Figure 3.3. Reported current and envisaged future technical skills mismatches



Source: RAND Europe analysis

Another factor that may influence the persistence of skills shortages could be related to the demographic profile of the workforce, whereby retiring experts are not replaced by newly trained workforce fast enough or with sufficient opportunity to allow for knowledge transfer and mentoring to upskill this next generation of experts to the required level. Particularly for skills that have a high degree of specialisation to defence, building up sufficiently qualified and experienced workforce can take significant amount of time, with some of the specialised skills requiring five or more years of training on the job to achieve full efficiency – or as many as fifteen or twenty years to become a leading expert in that field, able to lead, sign off and certify the work of others and exercise judgement on the most complex challenges (e.g. relating to safety, or deep technical complexity and uncertainty).

When timeframes for recruitment of skills are considered, the immediacy of demand for programme and project management skills becomes much more apparent for SMEs (up to 250 employees) and tier I and II suppliers (250-10,000 employees). Grouping by company size is simplified to enable ‘slicing’ the data from the survey data set in a meaningful way for comparison between company types. This grouping is not perfect and, of course, does not take into account many other characteristics of companies (beyond just employee numbers). It is recognised that there will be primes with less than 10,000 employees and SMEs will be characterised by other factors beyond just the number of employees, for example: annual turnover and total balance sheet.

The survey data revealed, that these companies report facing most immediate challenges in recruiting and retaining sufficient skills in areas such as:

- programme and project management,
- procurement and cost estimation
- systems engineering
- integrated test and evaluation

By contrast, the most immediate challenges for larger companies are within the technical fields, including:

- software design and engineering;
- synthetic environments engineering;
- design validation and planning;
- production support.

It is likely that programme and project management skills are well established in large companies but are becoming an increasingly challenging recruitment field for SMEs and other lower tier suppliers with the increasing number of collaborative programmes and more complex programme requirements. The delivery of such programmes requires not only improved technical skills (particularly in relation to design of architectures, integration of systems and their testing within a system of systems environment) but also management skills (including project management, cost estimation). Evidence shows that without these in place, delivering complex requirements within a system of systems environment is likely to cause delays and cost growth.⁷⁴

3.2.3. Domain specific skills mismatches

In addition to defence skills that cut across multiple domains, the project team has also sought to identify skills mismatches in those skills that are **unique to a defence domain**. While many of the gaps identified are in skills that require significant domain-specific knowledge, there are some common skills areas where mismatches are common across domains. These skills mismatches have been commonly reported across different defence domains (see Annex A for detailed information on skills mismatches per domain) and validated through stakeholder engagement interviews. The identified mismatches are:

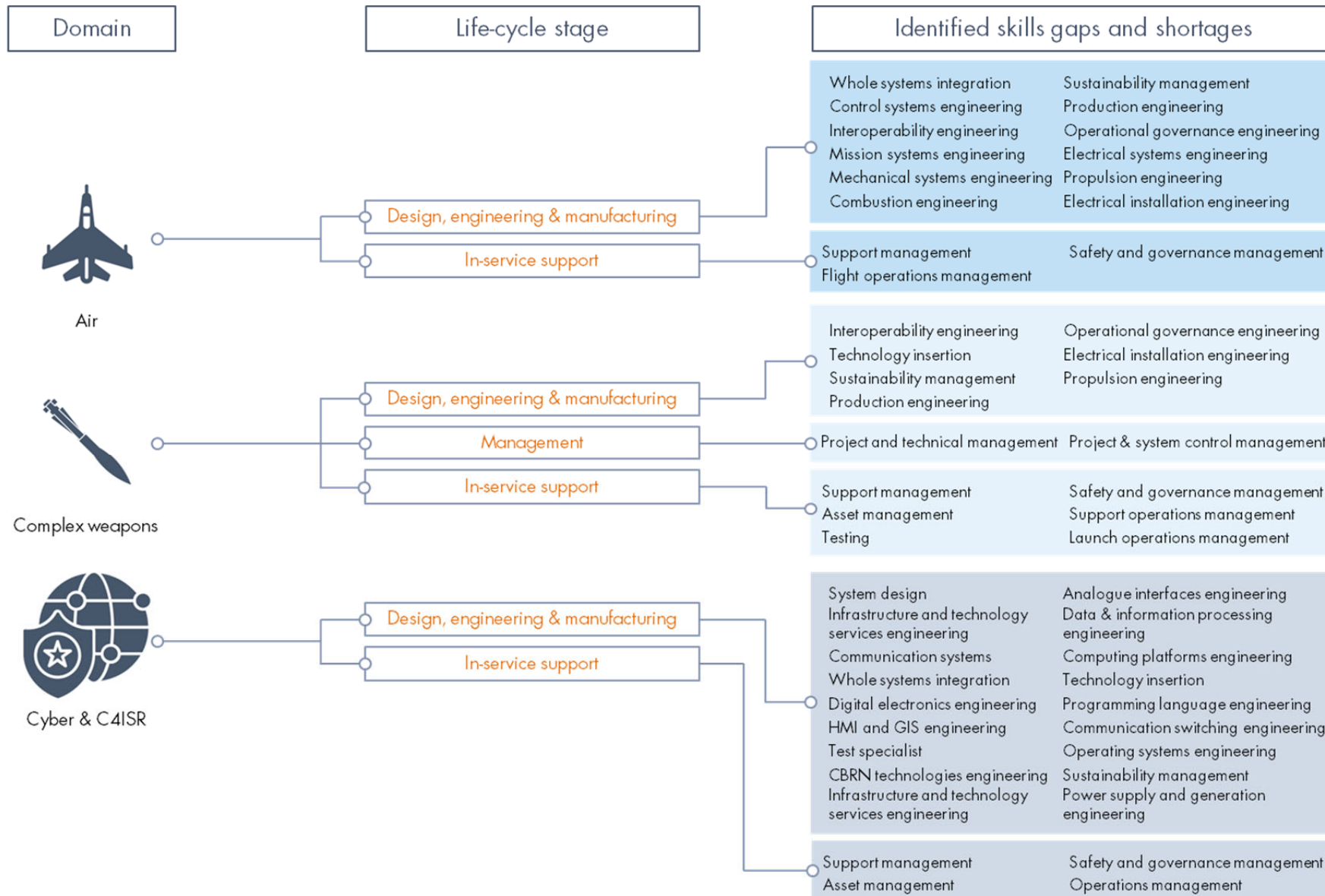
- **Interoperability design and engineering** skills are highlighted in multiple domains as a current and potential future shortage, echoing the increasingly collaborative nature of defence programmes as well as the interoperability needs between equipment and between different nations in deployed operations.
- **Safety engineering and governance** presents a skills area of concern, with challenges likely related to the increasingly complex safety and governance management and certification regimes related to the application of new technologies, as well as increasing interoperability requirements, the complexity of equipment design and the necessity to test and certify systems as they interact with each other in a system-of-systems environment. While new technologies offer new ways and means of testing and simulating the operation of new equipment designs, they also introduce new challenges in terms of the skills needed to interpret the profusion of data produced.
- **Whole system integration** is also noted as an area of skills challenge, which requires long-term expertise and understanding of the overarching architecture into which different systems fit – a

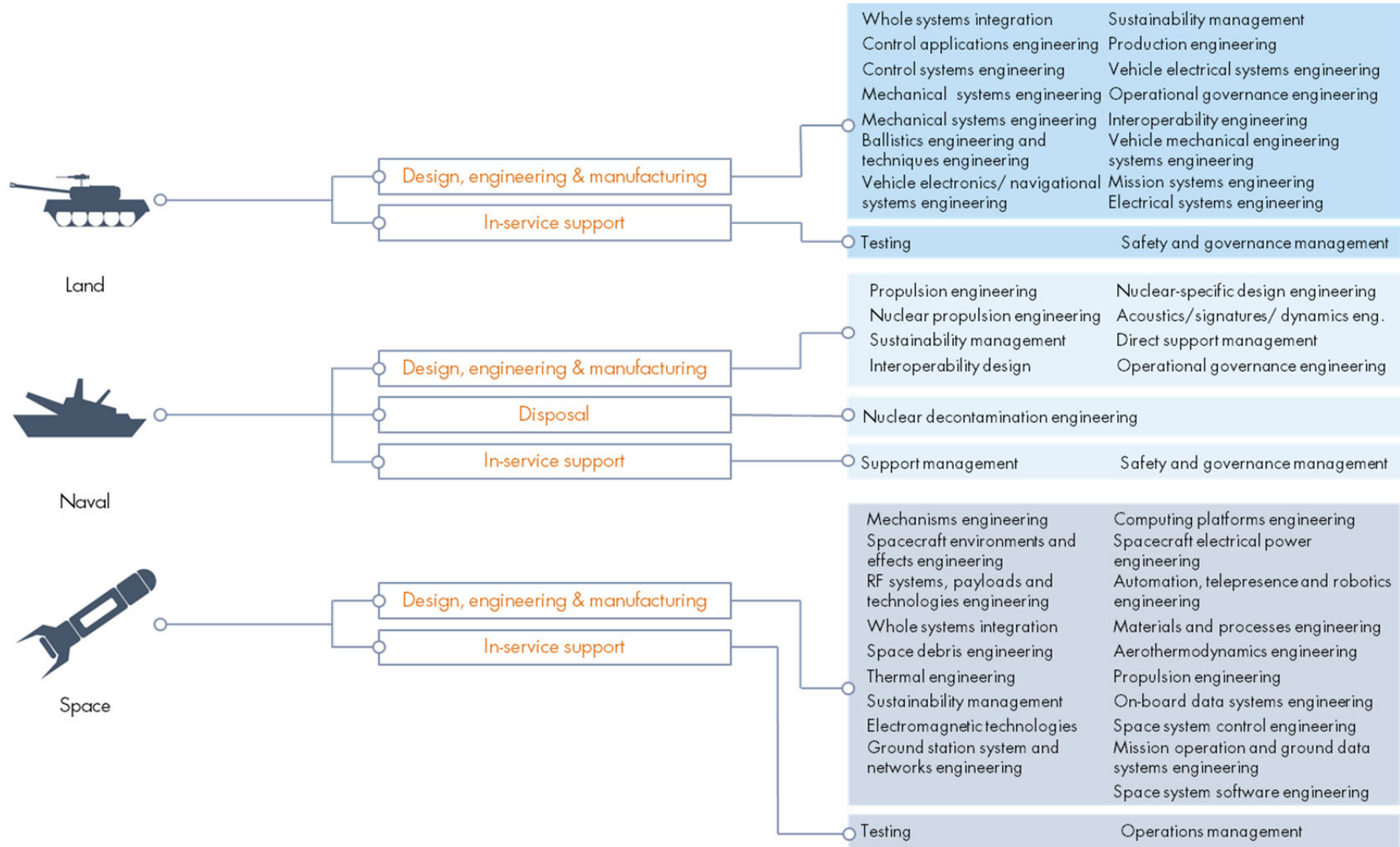
⁷⁴ Birkler, J., Schank, J.F., Arena, M.V., Keating, E.G., Predd, J.B., Black, J., Danescu, I.E., Jenkins, D., Kallimani, J.G., Lee, G.T., Lough, R., Murphy, R., Nicholls, D., Persi Paoli, G., Peetz, D., Perkinson, B., Sollinger, J.M., Tierney, S. & O. Younossi. *Australia's Naval Shipbuilding Enterprise: Preparing for the 21st Century*. Prepared for the Australian Department of Defence. RAND Research Report RR-1093-AUS. Santa Monica, CA: RAND Corporation

combination of skills, expertise and judgement that can only be gained through delivery of complex defence programmes and awareness of a wide range of different functional areas.

Most of the skills mismatches refer to internal skills gaps which means that companies are facing a situation where the type of skills of people do not match the requirements of the job or the level of skills is less than the level required to perform the tasks associated with the job satisfactorily. Given the domain specificity of the skills included here, this is not surprising, as there are only a few areas where skills can be sourced externally to the company. The most notable exception here is the cyber domain, where transferability of skills is significantly higher between the civil and defence sectors. In **Error! Reference source not found.**, skills mismatches are listed in detail, categorised by domain. It is important to note that the mismatches presented below represent the view of a relatively small number of companies, given the detailed breakdown of survey by domain expertise. However, they provide an indication of specific areas that can, in future research, be scrutinised further on an individual country or domain level. For the purposes of this report, the identified gaps and shortages act as a proxy to help build an understanding of the state of play of defence industrial skills in Europe.

Figure 3.4 Summary of defence domain-specific skills mismatches





3.3. Drivers of skills mismatches

3.3.1. Overview of drivers

The results of the research suggest that there no single reason that is perceived to drive skills mismatches but, rather, it is a combination of several, including:

- **A mismatch between employer needs and educational/training output** (in terms of both the volume and composition of the skilled workforce provided);
- **Stiff competition for skilled workers from non-defence sectors** – which includes perceptions of defence as unattractive, less dynamic and less well paid – suggesting an interplay between different, related drivers;
- **Demographic challenges**, particularly in relation to senior experienced workers who may be retiring without sufficient replacement and/or knowledge transfer;
- **Insufficient demand for skills utilisation due to low defence investment** nationally and/or on a European level (R&D, procurement) and/or low exports, undermining both the business case to retain these employees and the ability to test, build and develop their skills through hands-on experience on actual programmes.

3.3.2. Mismatch in education provision and industry needs, wage competition and lower attractiveness of defence

For all categories, survey respondents and interviewees have consistently reported **mismatch between skills supplied by educational and training institutions and employer needs**. Reporting such a mismatch is a common phenomenon identified in studies on skills mismatches.⁷⁵ Some mismatches exist for skills with low to medium level specialisation to defence, whereby graduate level courses are reportedly not aligned with industry needs. For skills that are specialist to defence, such mismatches refer to the lack of internal training programmes or mentoring schemes (as these skills are not supplied into defence industry from most graduate level education institutions).

Different factors are perceived to drive skills mismatches for technical defence skills at various levels of defence specialisation. For skills that are less specialist to defence (such as software design, composite fabrication engineering and autonomy engineering), the reported main drivers for skills mismatches include **wage competition** and **perception of defence as a less attractive sector**. This is not unexpected given these skills are likely to be more easily transferrable between sectors and can be found in civil sectors such as finance, automotive industry, engineering consultancies and others. As such, it is likely that multiple actors compete for the same pool of skills on the labour market at any one time.

⁷⁵ See for example: Gov.UK. 2017. 'UK Employer Skills Survey 2017'. As of 21st December 2018: <https://www.gov.uk/government/collections/uk-employer-skills-survey-2017>; European Commission. 2017d. 'Blueprint for Sectoral Cooperation on Skills: Responding to Skills Mismatches at Sectoral Level.' As of 28 September 2018: <http://ec.europa.eu/social/main.jsp?catId=1415&langId=en>

3.3.3. Low defence demand and demographic challenges

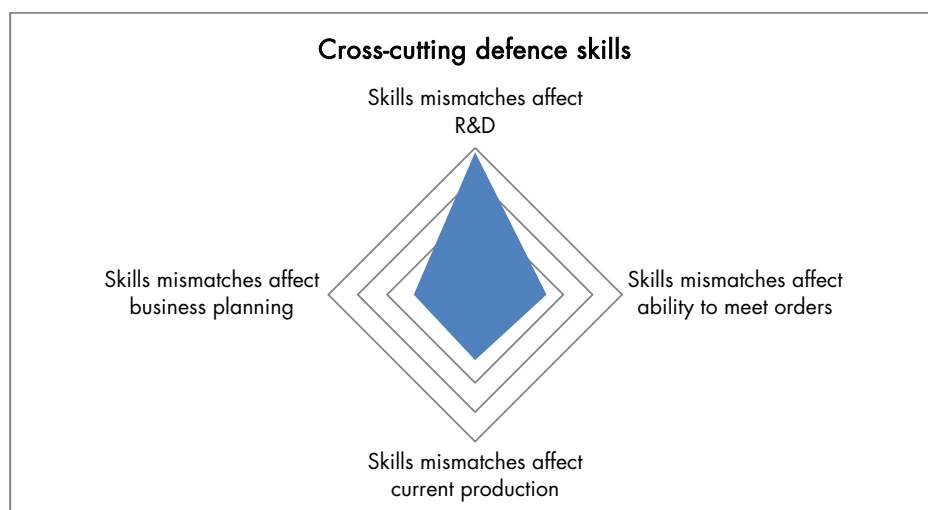
For skills with a higher level of defence specialisation (such as electronic warfare engineering, mission management and low observability design engineering), **low defence demand** (i.e. procurement and exports) and **demographic pressures** associated with retiring experienced workforce are also reported as important drivers behind skills mismatches. These skills tend to be nurtured through specific defence programmes and as such tend to be dependent on defence demand and expertise in house (which is often linked to years of experience). The usage of specialised skills depends on the extent to which they are required at a given lifecycle stage of a given project. However, if the skill is not required, it will, naturally, atrophy. The rate of atrophy will depend on a range of factors, including: the number, age and seniority profile of individuals possessing this skill within a particular company; the length of the ‘gap’ between programmes that require this skill; and the ability of a company to regenerate the skill through mentoring, traineeship or another form of internal skills transfer. Defence equipment programmes are important for retaining currency of skills and the ability to produce competitive defence products for the domestic and global customers.

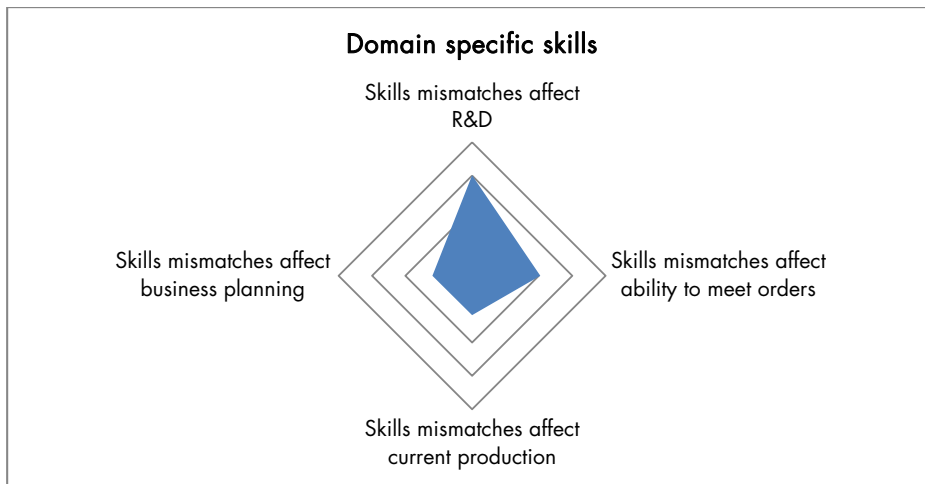
3.4. Potential impact of skills mismatches

3.4.1. Potential to undermine companies’ competitiveness and ability to innovate

Skills mismatches seem to present a persistent trend rather than a short-term, potentially cyclical phenomenon that can be resolved with temporary interventions. Responses provided by the survey participants support this hypothesis further, showing that reported skills gaps and shortages are perceived to have an impact on some of the core parts of the defence businesses, including R&D progress, delivery of orders and business planning (see Figure 3.5).

Figure 3.5 Perceived impact of skills mismatches





Note: the radar plots represent the frequency of reporting impact of skills mismatches for a long list of technical skills and domain-specific skills. It does not represent a quantified impact in monetary or other resource terms. Source: RAND Europe survey analysis

The most frequently reported impact is on R&D progress, which suggests that defence industrial innovation and delivery of advanced defence capabilities could be slowed down or thwarted due to the insufficient supply of relevant skills. This corroborates with the notion that most skills shortages and gaps are identified in the design and engineering. In addition to slowing innovation, skills gaps and shortages may have further effects on reducing competitiveness of the EDTIB and the quality of defence equipment. Finally, insufficient numbers and variety of R&D programmes, as well as not enough volume to develop skills, may lead to further skills shortages as fewer new programmes will mean fewer ‘exciting’ new opportunities for young STEM graduates and trainees to join defence. In this sense, there is a feedback loop between R&D programmes and skills supply in which the two reinforce each other – both in a positive and negative sense. Drawing on the analysis in Chapter 2, it is also important to note that the identified skills shortages and gaps can introduce additional risk, cost, schedule delays and product quality issues to defence programmes. This, in turn, will have an impact on European MODs and militaries in their ability to develop defence capabilities.⁷⁶

3.5. Further concerns with regard to skills

3.5.1. Uncertainty in relation to defence demand and competition for talent

As described in Chapter 2, EU defence industry often operates in an uncertain environment, with limited foreknowledge of upcoming defence equipment programmes. While some EU Member State governments provide an indication of their intentions in terms of future defence equipment programmes, the nature and timing of specific programmes is rarely specified. For many companies within the EDTIB,

⁷⁶ There is a vast volume of past RAND reports (many not publically available) articulating the link between skills and ability to deliver defence programmes in a range of domains. A useful summary of acquisition options, risks and opportunities and prerequisites (including skills) within the naval domain is available in: Schank, John, Mark Arena, Kristy Kamarck, Gordon T. Lee, Robert E. Murphy & Roger Lough (2014) *Keeping Major Naval Acquisitions on Course: Key Considerations for Managing Australia’s SEA 5000 Future Frigate Programme*, Santa Monica, CA: RAND Corporation, RR-767

future demand for their products is uncertain and confidence in relation to future defence programmes can be low.⁷⁷ This uncertainty relates to the number of platforms, their cost, design and manufacture schedule, delivery timeframe, workshare arrangements and technical requirements. All of these factors have implications relating to the volume of skills that are/will be required to design, manufacture and support the equipment as well as the technical complexity of such skills and their diversity (e.g. distribution across sites within one country or within Europe as a whole or distribution of work between an EU and non-EU nations).

Where national governments have explicitly committed to protecting certain capabilities and skills, domestic defence industry can have greater certainty about future skills requirements. However, these cases are not the norm and mostly relate to capability areas protected under national sovereignty and/or security of supply considerations. In an increasingly competitive defence market, defence companies are required to operate on limited information and thus assume risk in relation to retaining or recruiting skills they consider necessary for the delivery of a potential future programme. Given the requirement to compete for defence procurement contracts within and also outside the EU, the European defence industry will probably follow commercial motives when deciding whether or not to invest in the sustainment of defence specific skills or the recruitment of new ones. These motives may be informed by the degree to which companies are reliant on their defence business and whether they can leverage skills from within the civil part of their business or invest in retain or building up skills base that can transfer between the two parts.

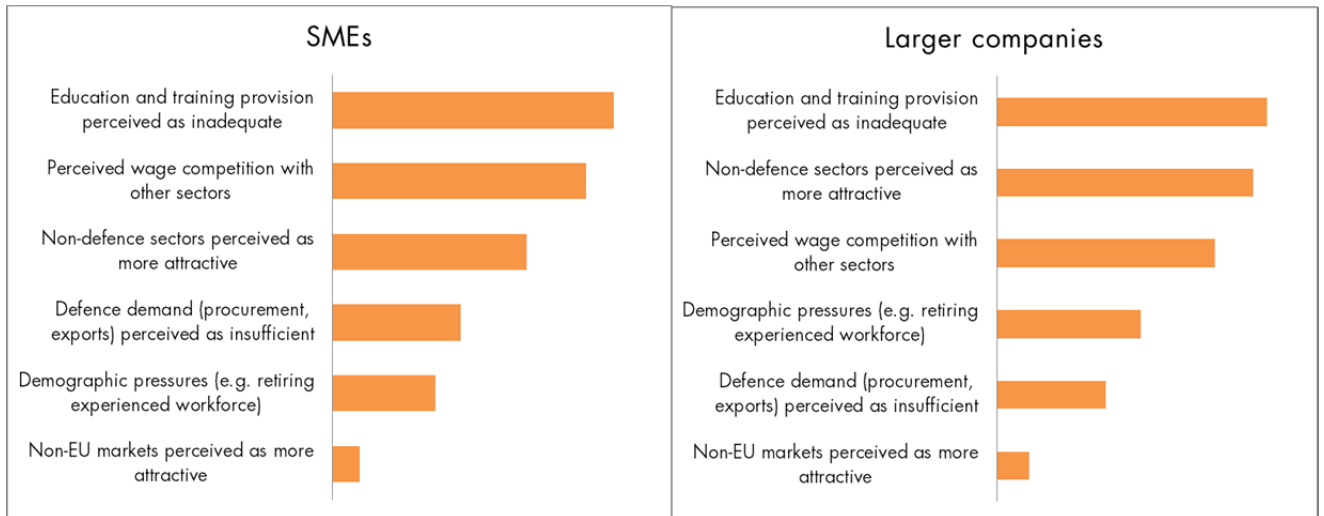
3.5.2. Differing concerns for SMEs and larger companies

While there are some similarities in the perceived reasons for skills mismatches by SMEs and larger companies, there are also notable differences.

Some similarities exist between the perceived reasons behind skills mismatches across different types of companies, with inadequate education and training being reported most frequently and closely followed by competition for talent with other sectors (see Figure 3.6). These factors were derived from previous work on defence skills shortages and triangulated with labour market experts in the EDSP. Interestingly, there is the relatively balanced picture of perceived reasons for skills mismatches reported by larger companies (with over 250 employees).

⁷⁷ Retter, Lucia, Louise Taggart, and Jon Freeman. 2015. *Key Skills and Competences for Defence: Annex E*, European Defence Agency, RR-1226-EDA. As of September 26, 2018: https://www.rand.org/pubs/research_reports/RR1226.html

Figure 3.6. Perceived reasons behind skills mismatches in skills by company size



Source: RAND Europe survey analysis

Note: the bars capture the frequency of responses

For SMEs, on the other hand, competition for talent, together with a perceived low attractiveness of defence work and some demographic pressures are seen to be critical factors in creating skills mismatches. With fewer resources than tier I, II and prime companies, SMEs are likely to face a fiercer challenge in both identifying and attracting talent into their defence work. Combined with perceived challenges related to the age and experience of subject matter experts, who may be too young and inexperienced or nearing retirement, SMEs may require support from primes as well as regional, national and supra-national bodies to put in place effective strategies to identify, attract and retain talent as well as to transfer existing knowledge effectively.

It is likely that defence capability development programmes act as a stronger determinant for skills needs for companies that focus primarily on the defence market than companies with a strong dual use or civil market presence, which may be able to draw on the workforce from across the different parts of their business. For these companies, the civil part of the business presents an opportunity, rather than ‘competition’ for skills.

3.6. Conclusion

The EDTIB needs a balanced skills base in order to develop, design, manufacture and maintain defence equipment and to deliver services for national ministries of defence, militaries and for exports. This skills base consists of a range of skills including technical, management and supporting skills as well as ‘new’ skills that enable defence industries to harness technological advances and remain innovative and competitive (for example digital skills, data analytics, software engineering, automation, cyber skills and others).

This chapter has identified a number of skills mismatches across defence skills that cut across multiple defence domains (i.e. cross-cutting skills) as well as domain-specific skills, management skills and ‘soft’ skills. Many defence specific mismatches are reported in skills categories such as systems engineering, test and validation, information architecture and safety which require significant knowledge of the

equipment/software at hand and in many cases, long term experience in working with these in order to be able to certify and sign-off on the design and the final product. Skills mismatches in less defence specific skills relate to managerial competences, administrative support and sales and marketing.

Stakeholders consulted throughout this project have reported different reasons for the existence of skills mismatches, including a perceived mismatch between education and employer needs, insufficient defence demand (i.e. procurement and exports), demographic pressures of ageing workforce and competition for talent with other markets – be it non-defence sectors, in or out of EU. Defence demand and demographics are perceived as key drivers behind skills mismatches for defence specific skills, while competition for talent with the wider labour market is seen as a more prominent driver for mismatches in transferable skills. Given this wide-ranging set of factors, any efforts to address skills mismatches will require a multi-faceted approach that is adapted to the context and the types of skills that are needed (e.g. technical or managerial or soft skills).

4. What strategies, policies, and initiatives form the European skills supply landscape?

This chapter discusses general features of the European defence industrial skills supply, focusing on the range of mechanisms that are in place to support it. Skill supply is assessed predominantly through a range of existing and planned EU, national, regional, and industry-led policies, programmes and initiatives. Section 4.2 presents an overview of existing EU-level policies, funding instruments and tools in the area of defence skills. Section 4.3 presents a qualitative mapping of educational and training programmes supporting the various stages of skills development in Europe. The initiatives in this chapter are broadly divided into ‘top-down’ – public educational programmes, national strategies, policies and initiatives on skills, which may be both academic and vocational in nature - and ‘bottom-up’ – industry-initiated skills activities which may be formal or informal in nature and can also include collaboration with government agencies or the education institutions. The following sections explore in detail the nature and focus of these existing educational and training programmes.

Any statements not specifically referenced in this chapter reflect the findings of RAND Europe stakeholder engagement (namely expert interviews and workshops with EDSP members). Insights obtained during the interviews are integrated throughout the report and the interview protocol can be found in Methodologies Annex.

Box 4.1 Chapter summary: What strategies, policies, and initiatives form the European skills supply landscape?

The defence skills landscape across the EU is shaped by the capabilities of each individual DTIB, national requirements, and the relationship between defence industry and government in each national context.

A succession of policy initiatives have shaped approaches to addressing defence industrial skills needs at the EU level

- Increasing recent focus of **EU-level policymaking** on defence and important initiatives, such as EDAP contributed to raising awareness about the funding opportunities and need to tackle skills challenges of the defence sector
- The EU provides several funding instruments and tools which can support industry in addressing its skills needs through various training, upskilling, and knowledge-exchange efforts

Mapping and analysis of educational and training programmes supporting the various stages of skills development in Europe revealed the following findings

- The majority of programmes are provided by **academic institutions**, while many large defence companies have their own **training centres**

- Most reviewed education and training programmes in Europe are civilian and dual-use in nature; most target **design, engineering and manufacturing**. Some education programmes integrate non-defence skills in defence education to harness skills relevant to defence industry
- A large proportion of workforce development happens **internally to companies** and as a result of the direct stimulus of domestic acquisition or foreign exports, when staff are working on equipment programmes and thus learning through a combination of hands-on experience, on-the-job training, formal mentoring and other practical learning opportunities
- Collaboration between industry, government bodies, and education sector could help address mismatches between skills provided by the education sector and the industry needs
- Mobility of students and free movement of workers in the EU has an impact on transferability of skills
- Finally, examples of good practice for sustaining, managing and retaining skills can be found in other sectors and geographies

4.1. Overview of defence industrial skills supply landscape

The concept of skills supply is used in the context of skills policy and research to indicate the type and volume of skills, competences and qualifications held by people in the labour market. In the context of this project, the concept of defence skills supply refers to the portion of the labour workforce (i.e. economically active people, including both employed and unemployed individuals) which has the ability to apply particular skill(s) or competence(s) relevant to the defence industry.

Skills is defined as “the ability to apply knowledge, use know-how to complete tasks and solve problems and carry out the tasks that comprise a particular job”

Competence is understood as “proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development.”

Source: European Commission; European Centre for the Development of Vocational Training

The development of highly specialised defence industrial skills can be a long process requiring many years of learning, training and practice. Furthermore, many niche defence skills may not be transferrable from other civilian industries, such as aviation, automotive or commercial shipbuilding. As a result, in most cases, specialised skills needed by the European defence industry are not provided by the education sector. Rather, to foster defence industrial skills and ensure their retention and transfer to new employees, a wide array of **early- and mid-career development initiatives** exist.

These initiatives can take the form of **industry-led initiatives**, but may also be the result of broader **EU, government, regional and local authorities’ investment programmes** in skills development, or of **joint civilian and military initiatives**.⁷⁸ Specifically, initiatives designed to sustain defence skills supply may take different forms across different levels of intervention, for example:

- **Supranational, national, regional and local strategies and policies** – strategies and policies adopted by public authorities at different levels to stimulate and sustain defence industrial skills supply;

⁷⁸ Retter (2015).

- **Vocational education** – apprenticeships and traineeships for entry-level employees, and military education programmes with relevant defence technical specialisation at different career levels;
- **Graduate education** – university-level education in disciplines relevant to defence industrial skills and university-level education delivered in partnership with defence industry or other universities (e.g. work placements, graduate schemes with industry);
- **Continuous education and vocational training** – ad-hoc training programmes, upskilling programmes for existing military personnel, as well as continuous development programmes for industry employees, in-house instructors, mentoring and knowledge transfer, etc.; and
- **External outreach** – outreach programmes for engagement, awareness-raising and early STEM skills development, including also engagement with groups under-represented in the defence industrial workforce (e.g. based on gender, ethnicity).

The defence-related skills supply landscape across the EU is shaped by the capabilities and defence market positioning (whether international, domestic, or regional) of each Member State's DTIB, as well as its relationship with national governments. National DTIBs, in turn, have evolved in response to the specific defence capability requirements and financial, human and technological resources of each MS. Therefore, each Member State has adopted its own unique approach to sustaining and developing defence skills, as a result of the local DTIB's characteristics and of specific national capability requirements. Large European companies as well as most SMEs, of which, according to DG GROW, there are at least 2,500,⁷⁹ are concentrated in only a handful of the EU MS: France, Germany, Italy, Spain, Sweden and the UK, driving a demand for a pool of employees with relevant skills and overlapping with the countries that host large relevant university programmes. These countries coincide with the prevalence of relevant reviewed programmes and also have a high employment in the defence industry. For example, while the total employment in the EDTIB in 2016 was estimated to be 843,000,⁸⁰ the number of direct jobs in the armament industry in France was assessed at 165,000,⁸¹ the employment in the defence and security industry in Germany at 135,700,⁸² employment in Italy at 45,000 people in the "core" value chain, the defence sector in the UK directly employs over 146,000 people⁸³ and the defence sector in Spain employs 210,000 people.⁸⁴

⁷⁹ European Commission, DG GROWTH, 'Defence Industries.' As of 11 January 2019: (Blog post) Roth, Alexander. 2017. 'The size and location of Europe's defence industry.' *Bruegel*. 22 June. As of 28 September 2018: http://ec.europa.eu/growth/sectors/defence_en

⁸⁰ ASD. 2017. '2017 Facts and Figures.' The Aerospace and Defence Industries Association of Europe. As of 23 October: <https://www.asd-europe.org/sites/default/files/atoms/files/ASD%20Facts%20and%20Figures%202017%20%28Final%29.pdf>

⁸¹ France Diplomatie. 2018. 'Defence industries and technologies.' As of 23 October: <https://www.diplomatie.gouv.fr/en/french-foreign-policy/economic-diplomacy-foreign-trade/supporting-french-businesses-abroad/strategic-sector-support/defence-industries-and/>

⁸² (Industry webpage) BDSV. 2018. 'Die Industrie.' As of 23 October: <https://www.bdsv.eu/themen/die-industrie.html>

⁸³ ADS Group. 2017. 'UK Defence Outlook 2017.' As of 28 September 2018: <https://www.adsgroup.org.uk/wp-content/uploads/sites/21/2017/09/DefenceOutlook2017-WebRes.pdf>

⁸⁴ Ministerio de Defensa. 2018. 'Catalogue: Spanish Defence Industry'. As of 23 December 2018: https://publicaciones.defensa.gob.es/media/downloadable/files/links/c/a/catalogue_dgam_17_18.pdf

At the same time, the accelerating pace of technological change, civil-led innovation, and adoption of new technology by the defence sector continues to impact the EDTIB, albeit at variable speeds and to differing levels when it comes to individual companies and even to individual engineering or management functions within each firm. Therefore, it is important to consider both the differing national contexts and the more cross-cutting impact of new technologies when designing any new skills sustainment and development measures at the European level.

Furthermore, there is scope to improve and standardise tools and mechanisms to assess skills development and classification at the European level. Although some professional associations provide formal assessment mechanisms for skills development throughout a number of EU countries (e.g. the UK Engineering Council, Colegio de Ingenieros de Caminos, Canales y Puertos, Austrian Defence Industrial Association (WKO ADIG), this is not the case for the vast majority of EU MS Defence Industrial Associations. The most common form of skills development mechanisms applicable in the majority of EU MS are degrees from universities and technical colleges that involve the use of formal examinations as a basis for skills assessment. Furthermore, individual companies measure skills development both formally and informally.

4.2. Existing EU-level policies, funding instruments and tools related to defence skills

This section identifies and characterises the policy initiatives which have progressively shaped the defence industrial skills landscape at the European level in recent decades, as well as the range of both dual-use and defence-specific funding instruments at the EU level upon which the EDTIB could draw to help tackle its skills needs. In addition, this mapping highlights the various tools which are available to stakeholders to facilitate access to these funding instruments.

4.2.1. Addressing defence industrial skills needs at the EU level

The recognition of the need to gain a better understanding of the skills required to sustain and strengthen the EDTIB has been gradually gaining prominence at the EU level. While the key trigger for EU-level developments was the adoption of the Defence Package in 2007 – which encouraged European competitiveness in the defence sector – the introduction of policies that directly target skills in the defence industry has been more recent.

Current European initiatives trace back to the 2013 Commission Communication ‘Towards a more competitive and efficient defence and security sector’. With this document, the European Commission adopted a more active role in the defence industrial policy area, and emphasised the value of building stakeholder networks and leveraging existing EU-level funding tools to address skills gaps and shortages through retention, up-skilling, and development of new skills. This two-pronged approach to defence industrial skills sustainment has been reiterated and reinforced in subsequent policy documents and initiatives, including, in particular:

- The Implementation Roadmap of the 2013 Communication (2014);

- The Blueprint for Sectoral Cooperation on Skills initiative of the New Skills Agenda for Europe (2016);
- The European Defence Action Plan (EDAP) (2016).

The EDAP is particularly significant in this regard, as it lays out a concrete plan to leverage the Blueprint to foster stakeholder cooperation in the defence sector, formulate a dedicated skills strategy, and fund pilot projects through Erasmus+ and COSME. The progression of key developments on the EU policy level is captured in Figure 4.1, while a more detailed description of relevant EU-level policies is included in Annex C.

Figure 4.1 Timeline of relevant selected EU-level policies



4.2.2. EU funding instruments and tools in support of skills

There are several EU programmes, tools, and instruments that can support the development and maintenance of skills in the European economy.

With the eligibility of defence sector employees and employers now clarified in successive European Commission policy documents following a period of uncertainty regarding the funding suitability of the defence sector, a number of these mechanisms can benefit the defence sector. Additional EU funding opportunities for the defence sector were presented with the launch of the European Defence Fund (EDF) in 2018, with the aim of increasing and maintaining the competitiveness of the EDTIB, and thereby enabling and indirectly benefiting the sustainment of skills in the defence sector.

In addition, there is a range of existing sector-neutral instruments that also provide support for the development of relevant skills and competences to defence-related stakeholders, such as governments, industry, universities, research institutes and others. Among these are the European Structural and Investment Funds (ESIF), Erasmus+ and COSME, described in this section, while a more detailed mapping of key EU-level funding instruments is presented in Table 4.1 below.

Table 4.1 Key EU- level funding instruments accessible for defence-related skills projects

Title	Description
European Structural and Investment Funds (ESIF)	
<ul style="list-style-type: none"> • <i>European Regional Development Fund (ERDF)</i> • <i>European Social Fund (ESF)</i> • <i>European Territorial Cooperation (ETC) programmes</i> 	<p>ESIF provides funding for projects aimed at job and skills creation and sustainment in the areas of research and innovation, digital technologies, supporting the low-carbon economy, sustainable management of natural resources, and. small businesses.</p> <p>ESF is one of five ESIF and the main EU funding instrument for investing in people. It finances interventions contributing to human capital development policies. The ESF has four key investment priorities (employment and mobility, better education and skills, social inclusion, and administrative capacity) and may fund projects supporting skills development also for the defence sector (e.g. building capacity in skills anticipation, or in dealing with potential skills gaps).</p> <p>The ERDF supports research and innovation, information and communication technologies (ICT), SMEs and the creation of a low carbon economy. The ERDF may fund defence activities and dual-use activities in research and innovation, as part of a national, or regional, smart specialisation strategy. For example, ERDF can contribute to overcoming barriers to growth for SMEs and can enable the defence sector to make use of the latest technologies (e.g. improving the use of ICT in the sector, especially in cyber security).</p> <p>The ETC programmes are funded by ERDF and thus comply with the same investment priorities as ERDF contributing to reaching smart, sustainable and inclusive growth.</p>
EU programme for Competitiveness of Enterprises and SMEs (COSME)	
<ul style="list-style-type: none"> • <i>European Strategic Cluster Partnerships incentive</i> • <i>European Cluster Collaboration Platform</i> <ul style="list-style-type: none"> ○ <i>Smart Specialisation Investments (ESCP-S3)</i> ○ <i>Going International (ESCP-4i)</i> 	<p>The COSME provides support to SMEs in 1) access to finance; 2) international links, exposure and access to markets; 3) business environment favourable to competitiveness; and 4) encouraging entrepreneurship. Private bodies, SMEs and state-owned enterprises are eligible for funding. Several cooperation networks, such as the Enterprise Europe Network, the European Network of Defence-related Regions and the European Defence Skills Partnership have been established and are funded by COSME.</p> <p>The European Strategic Cluster Partnerships incentive is part of COSME and aims at encouraging clusters across Europe to intensify collaboration across regions and sectors.⁸⁵ The European Cluster Collaboration Platform is providing services for cluster organisations. Currently there are two European Strategic Cluster Partnerships established: one is for Smart Specialisation Investments (ESCP-S3) and second for Going International (ESCP-4i). In 2017, defence-related clusters were eligible to apply for earmarked grants under the call for proposals ‘Clusters Go International in the Defence & Security sector’. The main objective was to support European defence and security-related clusters and business network organisations to intensify collaboration across borders with other non-defence industrial clusters and to develop and implement joint strategies in areas of dual use technologies, products and services towards non-EU countries. COSME also contributes to the Blueprint for Sectoral Cooperation on Skills which was launched as part of the New Skills Agenda with an overreaching aim to support sectoral strategies and to develop concrete actions to address short</p>

⁸⁵ European Cluster Collaboration Platform (Homepage). As of 24 December 2018: <https://www.clustercollaboration.eu/>

and medium term skills needs.

Erasmus+

Erasmus+⁸⁶

- *Strategic Partnerships*
- *Knowledge Alliances*
- *Sector Skills Alliances*

Erasmus+ is the EU's programme contributing to the Europe 2020 strategy for growth, jobs, social equity and inclusion, as well as the aims of the EU's strategic framework for education and training. Among its aims, it promotes adult learning, especially for new skills and skills required by the labour market and supports innovation and promotes cooperation and mobility with the EU's partner countries. Key Action 2 on Innovation and good practices is most relevant for the defence sector, as among its activities it includes: a) Strategic Partnerships to support innovation in the sector b) Knowledge Alliances to foster innovation in and through higher education together with businesses, and c) Sector Skills Alliances to tackle skills gap and ensure a better alignment of vocational education and training with labour market needs. These are aimed at skills needs identification and developing solutions for reducing identified skills gaps in the sector.

Horizon 2020

- *Knowledge and Innovation Communities (KIC) and the European Institute of Innovation and Technology (EIT)⁸⁷*
- *Marie Skłodowska-Curie actions*

Horizon2020 contains the following elements that can be relevant for the defence sector: research and innovation actions and Marie Skłodowska-Curie actions. The Horizon 2020 Work Programme from 2018 to 2020 introduces measures to support innovations that cut across technologies and sectors. Among its focus areas there are 'Digitising and transforming European industry and services' and 'Boosting the effectiveness of the Security Union' which are both directly relevant to the defence sector. Cybersecurity and digital security are among other support areas. There have been already several calls on cybersecurity projects (e.g. establishing and operating a pilot for a Cybersecurity Competence Network) a call on resilience in evolving ICT systems). Meanwhile, Marie Skłodowska-Curie Actions provide support to researchers to reinforce their career and skills through training, or periods of placement in another country or in the private sector. The new 2018-2020 work programme foresees such activities as the European Training Networks, European Industrial Doctorates, and staff exchange, which could be explored further in relation to the needs of defence related industries.

European Defence Fund (EDF)

- *Preparatory Action on Defence Research (PADR)⁸⁸*
- *European Defence Industrial Development Programme (EDIDP)*

Launched in 2017, the EDF will, once fully implemented, see the EU allocate a total of approximately €13 billion towards support for collaborative defence research, development and acquisition within the timeframe of 2021-2027, the period of the next Multiannual Financial Framework (MFF). Following the Preparatory Action on Defence Research (PADR), an annual average of nearly €600 million of EU funding will be channelled to collaborative defence research under the new MFF as part of the EDF's 'research window'. The collaborative research and capability projects supported by the Fund can foster knowledge exchange and skills development.

Source: RAND Europe analysis

⁸⁶ Erasmus (homepage). 2018. As of 23 October: http://ec.europa.eu/programmes/erasmus-plus/about_en

⁸⁷ European Institute of Innovation and Technology (homepage). 2018. <https://eit.europa.eu/>

⁸⁸ European Commission. 2018d. 'Preparatory Action on Defence Research (PADR)'. As of 21 December 2018: https://ec.europa.eu/growth/content/preparatory-action-defence-research-description-2018-topics_en

European Structural and Investment Funds (ESIF)

The ESIF have an important role to play in the development of skills and competences aimed at reducing economic disparities at regional level. Accordingly, the ESIF may be used by Member States to benefit the defence sector, as long as the funded projects contribute to the stated objectives of the respective fund. For example, defence-related industries can contribute to promoting the development of regional economies by investing in the defence supply chain if these investments contribute to skills, jobs, and technological and economic development and thus have wider economic and social benefits. Over the current EU budget period that runs from 2014 to 2020, the European Social Fund and the European Regional Development Fund (ERDF) are two of the ESIF under which activities related to skills and competences can be supported.

There are several examples of synergies across various funding instruments and of how ESIF have been used to fund dual-use activities with potential military applications. Importantly, defence projects are also beginning to be funded through ESIF. Table 4.2 lists selected examples.

Table 4.2 Examples of ESIF support to defence and dual-use programmes

Programme	Area	Description
Development of naval digital systems infrastructure	Naval	In 2015 the Naval Group (then DCNS) received ERDF support for infrastructure needed for naval digital systems ⁸⁹
Dual-use RDI projects complementary to Clean Sky 2 and its technical scope	Dual-use	In 2017 the national call in the Czech Republic supporting RDI projects had a total budget of 400 Million CZK (around €15.5 million) from the European Structural and Investment Funds. ⁹⁰
SPACE NOSTRUM – High Performance Dual Satellite Constellation for Maritime Surveillance	Space	Thales Alenia Space France leads a consortium of four other companies and two defence clusters and is supported by ESIF €0,5 million for a study supporting the development of a space satellite system with the aim to fight terrorism and smuggling ⁹¹

Source: RAND Europe analysis

Assistance with defence-relevant applications for ESIF funding can be provided by the EDA (for projects concerning defence-related skills and competencies), national MODs, other government agencies, local/regional agencies or authorities and specialised consultancies. Recent R&T proposals that have been successful in obtaining ESIF support focus on cyber defence training, satellite constellations for maritime surveillance, cyber conflict simulation, and improving the operation of remotely piloted aircraft systems

⁸⁹ Région Provence-Alpes-Côte D’azur. 2016. ‘Inauguration officielle du technocentre Henri Fabre : Bâtissons ensemble l’industrie du futur’. As of 25th December 2018: <http://prefectures-regions.gouv.fr/provence-alpes-cote-dazur/layout/set/print/Actualites/Inauguration-officielle-du-technocentre-Henri-Fabre-Batissons-ensemble-l-industrie-du-futur>

⁹⁰ (Industry web page)Clean Sky 2. 2018. ‘2017 Annual Activity Report’. As of 24 December 2018: http://www.cleansky.eu/sites/default/files/inline-files/CS-GB-2018-06-29-AAR-2017_20180706.pdf

⁹¹ ‘Key defence and security space project supported by ESIF.’ EDA: 29 November 2017. As of 19 December 2018: <https://www.eda.europa.eu/info-hub/press-centre/latest-news/2017/11/29/key-defence-and-security-space-project-supported-by-esif>.

(RPAS). Other projects that have received ESIF funding include examples in the related areas of energy, naval, robotics, components and modules, radio-frequency sensors, advanced materials and structures, communications and information systems.⁹²

Erasmus+ and COSME

Erasmus+ funding has also been awarded to relevant initiatives, including for example the transnational advanced Master course EMIMEO: ‘Erasmus Mundus on Innovative Microwave Electronics and Optics,’ which focuses on developing skills in a technology area that is critical to defence capabilities.⁹³ Similarly, COSME is supporting several networks aimed at strengthening the competitiveness and market access of dual-use SMEs and stakeholder networks, such as:

- **European Network of Defence-related Regions (ENDR):**⁹⁴ established in 2016, it brings together stakeholders (such as regional development agencies, clusters) familiar with the local ecosystem, who can identify sectors of higher potential use of dual technology and can contribute to incorporating defence-related elements in regional strategies. It provides a platform for collaboration and information sharing for regional authorities and clusters to share experiences and best practices in building dual-use strategies and accessing EU funding, particularly to the benefit of SMEs. ENDR disseminates information on EU funding.
- **Enterprise Europe Network (EEN):**⁹⁵ established in 2008, the EEN provides support to defence-related SMEs with activities such as networking and partnerships, internationalisation, technology transfers and finding business opportunities. It does this in particular through its Aeronautics, space and dual use sector group. EEN disseminates information on access to EU funding.
- **European Strategic Cluster Partnerships:**⁹⁶ this scheme offers opportunities for defence-clusters to link up with other economic clusters and better support SMEs in positioning themselves globally. In 2018 for the first time two Partnerships became active in an area of dual use⁹⁷.
- **European Defence Skills Partnership (ESDP):**⁹⁸ established in 2018, brings together industry, academia, authorities and innovation, research and vocational organisations to foster cooperation in building skills for the European defence industry. It is contributing to delivering a sectoral

⁹²European Commission. N.d. ‘European structural and investment funds’. As of 23 December 2018: https://ec.europa.eu/info/funding-tenders/funding-opportunities/funding-programmes/overview-funding-programmes/european-structural-and-investment-funds_en#investmentareas

⁹³ European Commission. N.d-b. ‘European Network of Defence-Related Regions’. As of 23 December 2018: https://ec.europa.eu/growth/sectors/defence/industrial-policy/endr_en

⁹⁴ European Network of Defence-related Regions (Homepage) 2018. As of 23 December 2018: <https://www.endr.eu/>

⁹⁵ Enterprise Europe Network (homepage). 2018. As of 23 October 2018: <https://een.ec.europa.eu/about/about>

⁹⁶ European Strategic Cluster Partnerships (homepage). 2018. As of 23 October 2018: <https://www.clustercollaboration.eu/>

⁹⁷ European Network of Defence-Related Regions. ‘New cross-border defence partnerships funded by COSME’. As of 23 December 2018: <https://www.endr.eu/news/new-cross-border-defence-cluster-partnerships-funded-cosme>

⁹⁸ European Defence Skills Partnership homepage (2018)

skills strategy and the developing and implementing scalable and sustainable solutions for new jobs and skills needs for the defence sector.

4.3. Analysis and mapping of educational and training programmes supporting the various stages of skills development in Europe

In addition to the EU-level policies, funding instruments and tools in the area of defence skills discussed above, the project team identified and reviewed 371 national, regional and company educational and training programmes across 16 representative EU MS.

Generally, there are different pathways for prospective and existing employees to obtain skills:

1. General education and training programmes providing general skills: initial provision of mostly **general skills** through vocational or university education (e.g. early career, internships);
2. Specialised training or up-skilling programmes: developing **sector-specific skills** through specialised programmes, vocational schools, apprenticeships;
3. Both of the above pathways may include collaborative activities between industry, government bodies, and education sector; most commonly such initiatives are aimed at **addressing skills gaps or mismatches**.

The variety of identified relevant defence related skills programmes and initiatives are captured in the Table 4.3 below as it provides an indication of the kinds of programmes available across different EU Member States.

Table 4.3 Scope of initiatives and programmes to foster defence related skills

Managing entity	Initiatives and programmes	Countries of operation
Industry	Total Industry programmes	
	Internal corporate training programmes and Employee up-skilling programmes	AT, DE, DK, ES, FR, IT, PL, UK
	Traineeship, apprenticeship and Internship programmes	AT, DE, FR, LT, NL, PL, SE, UK
	School and university placements and schemes	CZ, DE, ES, FR, NL, PL, SE, UK
	SME association programmes	AT, FI, UK
	Intra-industry (e.g. industry groups or associations) and intra-sector (e.g. land, air, sea) programmes	DK, NL, PL
Educational institutions*	Total Educational programmes	
	Vocational and technical college courses	IT, LT
	Defence academy and military staff college courses	AT, BE, CZ, ES, FI, FR, IT, LT, LV, NL, PL, SE, UK
	Undergraduate degrees	BE, DE, EE, FI, IT, LT, LV, NL, SE
	Postgraduate degrees	BE, DE, FI, FR, IT, LT, NL, SE, UK




	Early career education programmes	DE, FI, LV
	Mid-career education programmes	FR, IT, NL, UK
	Defence-related skill classification frameworks from defence-related professional bodies	DE, FI, UK
	Secondary school education and recruitment programmes	CZ, DE, ES, SE
Government	Total Government programmes	
	EU-led skills development programmes and policy frameworks	CZ, ES
	National government and ministry of defence-led programmes and policy frameworks	FR, IT, NL, SE, UK
	Regional or cluster-level development programmes and policy frameworks	DK, IT, LV
Other	Total other programmes	
	Research centre development programmes	DE, FR
	Jointly led associations or consortia	DK, ES, FI, IT, LT, PL, UK
	Dual-degree programmes that are jointly managed by defence companies with universities or technical colleges	AT, DE, EE, FR, NL, PL
	Cross-country education exchange programmes	AT
	External training organisation programmes	FI, FR, IT, NL
	Professional association qualification schemes	ES




Source: RAND Europe research



The review of skills programmes in the EU MS revealed a number of observations, which will be followed by more in-depth discussion in the following subsections.




Table 4.4 below presents a comprehensive mapping of the identified and reviewed top-down and bottom-up initiatives split by country and by type of initiative, while a full database of initiatives is available in the *Methodologies Annex B*.







Table 4.4 Mapping of identified and reviewed top-down and bottom-up initiatives



Country	National strategy			Identified top-down initiatives		Identified bottom-up initiatives	
	Skills focus in defence strategy	Industry/ domain specific	National strategy on skills	Education programmes	Other top down initiatives	Industry-led initiatives	Collaborative initiatives
Austria	-	-	-	✓	-	✓	✓
	Skills focus			Engineering, Mechatronics, Textile chemistry, Military science		Mechatronics, Electrical and mechanical engineering, Textile chemistry	Cyber security, Digital forensics, Engineering, Process technology, Metal technology
	Examples			Austrian Institute of Technology, Theresian Military Academy		SATTLER apprenticeships	SBA Research training programmes, Pankl-HBTL Kapfenberg Placements
Belgium	✓	-	-	✓	-	-	-
	Skills focus			Engineering, computer and data science, Electro-mechanical engineering, Space sciences, Nuclear engineering,			
	Examples			University of Liege, Royal Military Academy			
Czech Republic	✓	✓	-	✓	-	-	✓
	Skills focus			Electrical engineering			STEM skills, Business strategy and planning, performance measurement, cost optimisation
	Examples			University of Defence Brno, Military High School and College in Moravska Třebova			MEOPTA scholarship and study programmes, Honeywell Initiative for Science and Engineering

Country	National strategy			Identified top-down initiatives		Identified bottom-up initiatives	
	Skills focus in defence strategy	Industry/ domain specific	National strategy on skills	Education programmes	Other top down initiatives	Industry-led initiatives	Collaborative initiatives
Denmark	✓	✓	-	✓	-	✓	✓
	Skills focus			Systems engineering and design	Defence-domain -specific skills and knowledge	Management; avionics	Systems engineering & design, mechanical and production engineering
	Examples			Defend Arktis, Haderslev Municipality, Aeronautical Center of Excellence	The Danish Defence Acquisition and Logistics Organisation	Mercantec and Scandinavian Avionics, Space and Aerospace Cluster	Innovation Network Production, Drone Countermeasures Project
Estonia	✓	✓	-	✓	✓	-	-
	Skills focus			Cyber and information technology, Integrated engineering, International business administration	Defence-domain -specific skills and knowledge		
	Examples			Tallinn University of Technology	MOD-industry-academia cooperation working groups, Tallinn University of Technology		
Finland	✓	✓	✓	✓	✓	✓	✓
	Skills focus			Cybersecurity and Information Technology including coding	Military science and artificial intelligence	Operational skills related to training in aerospace/naval	Computer science and coding, future technologies
	Examples			Kymeenlaakso University of Applied Sciences, Aalto University	Finnish Center for AI	Patria, Robonic Company, Surma	MyTech, Saab and Aalto University, Aalto University and Accenture

Country	National strategy			Identified top-down initiatives		Identified bottom-up initiatives	
	Skills focus in defence strategy	Industry/ domain specific	National strategy on skills	Education programmes	Other top down initiatives	Industry-led initiatives	Collaborative initiatives
France	✓	✓	-	✓	✓	✓	✓
	Skills focus			Engineering; propulsion, naval architecture; sensors, geolocation and navigation; complex systems; CBRN	Practical technical training, in-service support and operations	Cross-functional skills; management; in-service support; testing; design;	Engineering; project management; energy production systems and platforms; nuclear technology
	Examples			ISAE-SUPAERO MSc, Advanced Masters at the ENSTA Bretagne	Institut des hautes études de défense nationale (IHEDN); French Naval Academy	Safran Helicopter Engines Academy, apprenticeships (Dassault, Thales), Naval Group Professional Bridges, CambusFab training platform	ENSTA Bretagne, AEROCAMPUS Aquitaine
Germany	✓	✓	-	✓	✓	✓	✓
	Skills focus			Engineering; technology (aircraft, naval, microsystems, energy); communications systems, integrated systems, digitalisation, IT		Generic engineering skills, mechanical engineering, industrial engineering, management, computer science, vessel systems, mine warfare, submarine systems, naval weapons, mathematical engineering	
	Examples			TU Munich Aerospace Engineering MSc, TU Dresden Computational Science and Engineering, UNIBW MSc Cyber Security, TU Munich Robotics	DLR School Labs, DLR: undergraduate, doctoral degrees, dual degree, apprenticeship	Next Gen Engineering Defence, TKMS Technical Graduate Program, Lürssen Dual Degree Program, MTU Dual Degree Program, MBDA Dual Degree Program, Rheinmetall Dual-Degree Program	

Country	National strategy			Identified top-down initiatives		Identified bottom-up initiatives	
	Skills focus in defence strategy	Industry/ domain specific	National strategy on skills	Education programmes	Other top down initiatives	Industry-led initiatives	Collaborative initiatives
Italy	✓	-	-	✓	✓	✓	✓
	Skills focus			Aerospatial engineering, Naval ship engineering, Electronics, Cyber security, Aerospace management	Small arms technician skills, Aerospace electronics, technical skills	Aeronautical engineering,, small arms technical skills, defence equipment maintenance skills, software skills	
	Examples			School of Aerospace Engineering, Sapienza University of Rome, University of Naples, University of Perugia	Ministry of Defence	Leonardo Training Academy, Ficantieri training and development initiatives, Ficantieri Corporate university, training projects within the Lombardia Aerospace Cluster	
Latvia	✓	-	-	✓	-	-	-
	Skills focus			Engineering sciences, Aviation transport, Computer science, Management, Ship electronics and seaworthiness, robotics, material science, automotive engineering			
	Examples			Riga Technical University, University of Ventpils, National Defence Academy of Latvia			
Lithuania	-	-	-	✓	-	-	✓
	Skills focus			Computer science and software engineering, Defence technology management, Aviation and Avionics, Sea port engineering, Transport engineering, Laser physics and optical technologies,			Laser technology, Optoelectronics, cyber security, Air traffic support and radars
	Examples			Vilnius Gediminas Technical University, Kaunas University of Technology, Vilnius University, General Jonas Žemaitis Military Academy of Lithuania			Lithuanian defence and security industry association, Lithuanian Laser Association

Country	National strategy			Identified top-down initiatives		Identified bottom-up initiatives	
	Skills focus in defence strategy	Industry/ domain specific	National strategy on skills	Education programmes	Other top down initiatives	Industry-led initiatives	Collaborative initiatives
 Netherlands	✓	✓	✓	✓	✓	✓	✓
	Skills focus			Design and engineering (aerospace, computer, electrical, materials science, mechanical), marine technology, management	Engineering (space, mechatronics, aerospace); technical skills	Engineering, marine technology, cloud security, cyber, software, 3D simulations, gaming, VR	Systems engineering & design, mechanical and production engineering
	Examples			Royal Institute for the Navy Military Scientific Training, 'DARE' Aerospace Rocket Engineering, TU Delft Aerospace Engineering MSc	VEVA Defence-specific Vocational Training Programme, NLR Internship programme	FoxAcademy; EC-Council Certified Ethical Hacker Programme, Damen and KMWE Traineeship	TNO Traineeship, TNO Internship
 Poland	-	✓	✓	✓	✓	✓	✓
	Skills focus			Design and engineering; cybernetics, defence planning, information security, management	System for supporting aerospace industry	Mechanical motoring, chemistry, battery development	Engineering skills
	Examples			Mechanical Engineering (Military Technical University)	Polish Aviation Valley Association	PZL-Świdnik internship, Łucznicz Arms Factory professional internship	PGZ scholarship program for university students
 Spain	-	✓	-	✓	✓	✓	✓
	Skills focus			Engineering; management and systems	Engineering (Building Information Modelling)	STEM skills, coding, robotics, electronics	Naval skills and shipbuilding
	Examples			University Center of the Defense of San Javier, Centro Universitario de la Guardia Civil, CESDEN, CUD	Institute of Engineering in Spain (IIE)	Indra Smart Start, SASCorp MakerLab, SASCorp's Maker Labs	Navantia Strategic collaboration, UDC Joint Research Unit, Airbus Minds Programme

Country	National strategy			Identified top-down initiatives		Identified bottom-up initiatives	
	Skills focus in defence strategy	Industry/ domain specific	National strategy on skills	Education programmes	Other top down initiatives	Industry-led initiatives	Collaborative initiatives
Sweden	✓	✓	-	✓	✓	✓	✓
	Skills focus			Design and engineering (aerospace, maritime, weapons systems, mechanical, automation, mechatronics, industrial), disposal, project management, software engineering	Cyber	General engineering, software engineering, cyber, management	Design, engineering, management
				Examples			KTH Aerospace Engineering MSc, University of Gothenburg Software Engineering and Management BSc, Chalmers Naval Architecture and Ocean Engineering MSc
UK	✓	✓	✓	✓	✓	✓	✓
	Skills focus			Systems engineering, cyber, defence modelling and simulation, military airworthiness, military analysis & problem-solving, explosives & CBRN forensics	General STEM skills; engineering; cyber	General STEM, manufacturing, systems engineering & design, software engineering, hardware & sensors engineering, weapons systems	Cyber, digital, engineering & technical skills, systems engineering, defence modelling & simulation, CBRN forensics
				Examples			MBA Defence (Cranfield University); Defence Technical Officer and Engineer Entry Scheme (Wellbeck College); Post 16 technical education T-skills plan

Source: RAND Europe analysis

The following six sections draw out the main features of the skills programmes analysed for this project. The remainder of this chapter also identifies key observations applicable to all MS considered in this project and highlights good practices that have emerged in the course of skills programmes analysis.

4.3.1. Education and training programmes provided through academic institutions and internal corporate training centres

The majority of reviewed top-down initiatives are provided by academic institutions, such as civilian universities, military colleges, and defence academies. In addition, other initiatives are provided by vocational or technical schools, high schools, and other educational establishments and institutes. As for the private sector, larger and more streamlined training programmes are provided by large defence companies, many of which have their own training academies that focus on training and up-skilling the employees of the company (often including the workers of the company's civilian branch). While most programmes are delivered as part of in-house training, in several instances programmes provided by large companies rely on external expertise acquired from independent commercial training centres. While there may be a tendency for large companies to have better established links with training institutions in the form of, for example, apprenticeships and work placements, visiting lectureships, recruitment initiatives, career fairs and scholarships, many defence SMEs also offer internships and engage in cooperation with academia and training organisations proactively in order to encourage innovation and skills.

4.3.2. Dual-use programmes and those integrating non-defence skills in defence education

Most of the reviewed programmes are provided by civilian universities that cater for a wide range of skills demands from many sectors of the economy. Many of the more niche defence-specific skills (e.g. reheat and low observable design for military engines – neither skill is needed for or present in civil aviation) are instead developed through years of practical experience and on-the-job training within the defence industry, rather than through more theoretical learning in a university or technical college. Such niche skills are mostly acquired through internal company training and mentoring. Other defence-sector specific skills are offered through military educational institutions (military colleges, academies, universities and Armed Forces training centres). While some defence-industry relevant university-level programmes that are open to civilian students were identified (e.g. higher education programmes in various engineering disciplines), these programmes are mostly aimed at cadets who are preparing for military service or offer skills upgrade or certification for serving military personnel (e.g. in ship seaworthiness, information security or dealing with unexploded ordnance). The skills and defence domain knowledge acquired during such programmes may trickle into the defence industry after the person left active military service, but have therefore only an indirect impact on the industrial skills base.

The majority of the programmes reviewed focus on developing skills related to design, engineering and manufacturing of defence industrial products, while programmes with a focus on the management stage are also prevalent in the EU MS. However, most programmes do not identify a focus on a specific defence industrial lifecycle stage which can be explained by the prevailing dual-use nature of programmes reviewed, as well as the transferability of many basic skills and principles across multiple lifecycle stages (e.g. synergies between production and some support work).

4.3.3. Workforce development through internal company programmes

The reviewed practices revealed the **added value associated with on-the-job experiences that programmes' beneficiaries are able to make through most industry-led programmes**. Although there is limited evidence of mid-career development opportunities that are as well-developed and publicised as early-career development programmes, upskilling development opportunities are more visible in-house. Mid-career development programmes seek to maintain and tailor the required skillsets as the external environment and capability development needs evolve. Some companies also strategically develop specialised training, not only to ensure that employees are able to fulfil their roles, but also so that employees maintain the transversal skills to operate across business segments and maintain flexibility and breadth of skills. Skills programmes carried out by the industry are particularly significant, due to the defence-specific character of many skills that are not provided by the education sector.

4.3.4. Collaboration between industry, government bodies, and education sector

Collaborative initiatives are amongst some of the most effective ways of identifying possible future skills gaps and addressing the challenges associated with skills mismatches. These can include public-private collaborations through training, education programmes, and internships. Examples include the Rheinmetall Dual-Degree Program (Germany), training projects within the Lombardia Aerospace Cluster (Italy) and Saab Technology Leap internships (Sweden). The other type of collaboration may involve private-academic partnerships through training, education and skills promotion programmes and activities. Here examples include Junction hackathon hosted by the Aalto University in Finland which attracts multiple industrial participants and partners, such as Accenture, Vaisala, Cisco, Rightware, Smartly.io, and Supercell. The establishment of **skills or innovation hubs that place academia, government and industry in close geographic proximity** supports the acceleration of knowledge transfer, networking and cooperation between stakeholders to support the development of defence-related skills. For example, in Germany, the concentration of major defence companies, technical universities, vocational colleges and networking events in Bavaria has increased collaboration and the likelihood of developing jointly-governed programmes.⁹⁹ **Building new or reinforcing existing communities promotes peer and social learning of skills and competences**. While the so-called communities of practice (i.e. self-organising and self-governing groups of people who share a common concern, a set of problems, or interest in a topic and who come together to fulfil both individual and group goals)¹⁰⁰ have been widely used in a number of fields (e.g. evaluation, international development, education, health and healthcare) to facilitate multi-professional information and knowledge sharing,¹⁰¹ in the context of defence skills supply, some learning communities have already emerged through online fora and websites. This is particularly prominent for

⁹⁹ Dürselen, G. 2018. 'Die Rüstungsindustrie boomt in Zeiten von Kriegen.' *Neues Deutschland*, 15 February, 5:24 p.m. As of 18 September 2018: <https://www.neues-deutschland.de/artikel/1079584.deutsche-friedensgesellschaft-die-ruestungsindustrie-boomt-in-zeiten-von-kriegen.html>

¹⁰⁰ Wenger, E., McDermott, R., & Snyder, W. M. (2002). *Cultivating communities of practice* (1st ed.). Watertown, MA: Harvard Business School Press.

¹⁰¹ Garrod, Bryn and Tom Ling. 2018. 'System change through situated learning: Pre-evaluation of the Health Innovation Network's Communities of Practice'. *RAND Europe*. As of 23rd December 2018

cyber-related skills, for example, as these are often considered to be better acquired outside traditional university education.

In addition, Research and Development (R&D) coordination and management is mainly conducted via partnerships between industry and academia, a trend observable across Europe. A more detailed discussion on the existing efforts and models to coordinate R&D and management with competencies and skills sustainment and development is included in Section D.3.2 of Annex D.

However, **the landscape of industry-led skills supply initiatives is characterised by fragmentation and competition** and this has negative repercussions in terms of **missed economies of scale and duplication of efforts**. The risk of missed economies of scale and duplication of efforts is particularly heightened when strict divisions of labour between the ministries of defence and education in government hamper oversight and accountability over defence skills requirements.

4.3.5. Importance of strengthening mobility and exchange in defence to help develop and sustain skills

A factor that is related to the transferability of skills is the mobility of students and EU labour mobility, impacted respectively by such aspects as the availability of specific programmes in the home country of the student, the quality of the programme, language of instruction and potential career opportunities, professional goals, salary considerations.

The level of specialisation of the educational institutions in the EU MS impact whether or not the country is able to attract students in specific programmes. According to Eurostat data, “Engineering, manufacturing and construction” is the second most popular area of studies for students from abroad (16.7 per cent of students from abroad) and “Natural science, mathematics and statistics, information and communication technologies” were the fourth most popular topics (13.2 per cent).¹⁰² For example, Germany hosts a large number of STEM-related programmes and boasts one of the highest percentages of foreign students specifically in engineering, manufacturing and construction. On the other hand, while **Germany, the UK, Spain, Italy and France** have been among the countries with the largest number of active movers across occupations, according to a report published by the European Commission, a comparatively low number of movers work in technical occupations. This includes plant and machine operators and assemblers, technicians and associate professionals (each less than 10 per cent of employees), craft and related trades workers (less than 15 per cent) and professionals (less than 20 per cent of movers).¹⁰³ In combination with the inherent sensitivity of information pertinent to the defence sector and, in many cases, nationality or security clearance requirements, this information implies that **there is relatively low EU labour mobility in the defence industry**.

However, research conducted on cyber, naval, and aircraft defence industry suggests that members of specialised workforce within such industries may move across different areas of a given defence domain

¹⁰² Eurostat. 2015. ‘Share of tertiary education graduates from abroad by field.’ As of 18 October 2018: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Share_of_tertiary_education_graduates_from_abroad_by_field,_2015_ET17.png

¹⁰³ European Commission. 2018a. ‘2017 Annual Report on intra-EU labour mobility.’ As of 24th December 2018: https://ec.europa.eu/futurium/en/system/files/ged/2017_report_on_intra-eu_labour_mobility.pdf

(e.g. working on different platforms) as well as across related defence and civilian industrial sectors.¹⁰⁴ The transferability of industrial and technology skills and competences between defence and civilian sectors and the positive impact that defence industrial developments can attain has already been observed at a European level, such as Sweden's Gripen Programme, the UK Bombardier Aerospace Apprenticeship and Graduate programmes. Transferability of skills in the defence domain and between defence and civilian sectors is discussed in more detail in Section B.1 of Annex B.

4.3.6. Examples of good practice for sustaining, managing and retaining skills from other sectors and geographies

Although Chapter 2 has identified the unique characteristics of the defence sector, it also has a number of linkages to commercial industries, both in terms of technological similarities and skills requirements and challenges. In addition, other jurisdictions may prove valuable sources of good practice, in particular the US with its world's highest defence budget and the largest DTIB and the world's leading defence suppliers.

Although experiencing similar retention challenges to the defence sector, **the high-tech and IT industries make more use of digitally-facilitated employee engagement tools to help prevent employee attrition.** Several high-tech, IT and defence companies publicise their activities in experimental innovation and initiatives that show leadership in technology advancements. Amazon Robotics markets itself as “the epicentre of robotic innovation”¹⁰⁵ while DeepMind pursues artificial intelligence research and development leveraging the market knowledge and talent of Google - its parent company.¹⁰⁶ Similarly, defence companies seek to project an innovative image, such as Saab's R&D activities in graphene, or Rolls-Royce's pioneering role in 3-D printing.¹⁰⁷ One business practice that features more prominently in the high-tech and IT industries as opposed to the defence sector is the specialisation of retention strategies for high-performing talent. The identification of these individuals and the enforcement of targeted

¹⁰⁴ Bassford, M., Pung, H., Edgington, N., Starkey, T., Weed, K., Arena, M.V., Kallimani, J.G., Lee, G.T. & O. Younossi. 2010. *Sustaining Key Skills in the UK Military Aircraft Industry*. Prepared for the United Kingdom Ministry of Defence. RAND Research Report MG-1023-MOD. Santa Monica, CA: RAND Corporation; Keating, E.G., Danescu, I., Jenkins, D., Black, J., Murphy, R., Peetz, D. & S.H. Bana. The Economic Consequences of Investing in Shipbuilding: Case Studies in the United States and Sweden. RAND Research Report RR-1036-AUS. Santa Monica, CA: RAND Corporation; Silfversten, E., Flint, R., Lynch, A., Ward, A. & A. Hall. Forthcoming (2018). *Cyber Defence Specialist Models (CD SpecMods)*. Prepared for the European Defence Agency. Reference: 17.CAT.NP3.081. Not for public distribution.

¹⁰⁵ (Industry webpage) Amazon Robotics. 2018. ‘Our Vision.’ As of 22 October 2018: <https://www.amazonrobotics.com/#/vision>

¹⁰⁶ (Industry webpage) DeepMind. 2018. ‘About DeepMind for Google.’ As of 22 October 2018: <https://deepmind.com/applied/deepmind-google/>

¹⁰⁷ (Industry webpage) Saab. 2015. ‘Innovation in every fibre.’ As of 22 October 2018: <https://saabgroup.com/media/stories/stories-listing/stories-of-innovation/innovation-in-every-fibre/>; (Industry webpage) Rolls-Royce. 2018. ‘Taking 3-D printing to new heights.’ As of 22 October 2018: <https://www.rolls-royce.com/media/our-stories/innovation/2017/alm.aspx#overview>

retention interventions for these groups could be conducive to higher retention rates.¹⁰⁸ In some non-defence industries, employee retention strategies are not aimed at individuals, but rather generations: Baby Boomers, Generation X and Millennials.¹⁰⁹

The US defence skills landscape is characterised by large-scale capability programmes and high levels of regional (state) focus. Differing from the European approach in a number of key ways, **the US approach to defence skills development offers valuable examples of good practice.** First, with more formal mechanisms in place at the national level, the US government agencies are able to facilitate greater collaboration between government bodies, industry and academic organisations, both in terms of identifying and addressing skills gaps through general strategies. At the same time, there is a prevalence of skills programmes that are administered at the regional or local level. As skills programmes are often driven by local industry needs, a larger number of defence-specific programmes target school-aged children. While this does occur in a limited sense within the EU, with an illustrative example being the Saab-led initiatives in Sweden, the majority of industry-led schools programmes target more general STEM skills. The US also places great emphasis on regional hubs and centres of excellence. While this approach is shared by many European MS, in the US, these regional hubs appear to be more closely linked throughout the country. The US also has a large number of specialised defence colleges, reflecting the size of the country's military and defence budget. Similar to Europe, the US DoD has identified cyber skills as a priority area for defence.¹¹⁰ The defence-specific cyber skills initiatives that have been implemented by the DoD appear to have experienced relatively high levels of success¹¹¹ and may offer useful insights into best practice for similar initiatives in Europe.

4.4. Strengths, Weaknesses, Opportunities, Threats (SWOT) analysis

Having conducted the mapping of selected policies, strategies and initiatives across representative European MS, it is possible to draw qualitative conclusions based on the main characteristics of reviewed initiatives. Box 4.2 below summarises the main internal factors that characterise a successful education

¹⁰⁸ Cosack, Sabine, Guthridge, Matthew, and Lawson, Emily. 2010. 'Retaining key employees in times of change.' As of 22 October 2018: <https://www.mckinsey.com/business-functions/organization/our-insights/retaining-key-employees-in-times-of-change>

¹⁰⁹ Kwan, Alice, Pellster, Bill, Neveras, Neil, Erickson, Robin, Schwartz, Jeff, and Szpaichler, Sarah. 2012. 'Talent 2020: Surveying the talent paradox from the employee perspective.' As of 22 October 2018: https://www2.deloitte.com/content/dam/Deloitte/mx/Documents/about-deloitte/Talent2020_Employee-Perspective.pdf

¹¹⁰ Department of Defense (DoD). 2018. 'Fiscal Year 2017: Annual Industrial Capabilities'. As of 23rd October 2018: <https://www.businessdefense.gov/Portals/51/Documents/Resources/2017%20AIC%20RTC%2005-17-2018%20-%20Public%20Release.pdf?ver=2018-05-17-224631-340>; (Blog post) Cebul, Daniel. 2018. 'More universities to offer Hacking for Defense program'. Fifth Domain. As of 23rd October 2018: <https://www.fifthdomain.com/workforce/education-training/2018/04/03/more-universities-to-offer-hacking-for-defense-program/>; (Industry web page) Cyber Patriot. N.d-b. 'What is Cyber Patriot'. As of 23rd October 2018: <https://www.uscyberpatriot.org/Pages/About/What-is-CyberPatriot.aspx>

¹¹¹ (Industry web page) Cyber Patriot. N.d-c. 'Impact'. As of 23rd October 2018: <https://www.uscyberpatriot.org/about/impact>

training or programme, also calling out some of the weaknesses that may hinder the ability of an initiative to address the needs of the defence industry for relevant skilled personnel today and in the future.

Box 4.2 Internal factors that characterise skills initiatives – strengths and weaknesses

Identified strengths of the EDTIB's skills initiatives

- Industry-led initiatives have capacity to respond more rapidly and suitably to industry's needs, including for emerging and changing industrial and technological needs
- Industry programmes that offer on-the-job experiences have proved particularly effective
- Several countries offer programmes that cover both academic and on-the-job activities
- Most programmes foster dual-use skills, benefitting European industry beyond the defence sector

Identified weaknesses of the EDTIB's skills initiatives

- The landscape of industry-led skills supply initiatives is characterised by fragmentation (reflecting competition between firms) which results in missed economies of scale and in duplication of effort
- The lack of sufficient coordination within industry and between industry and public authorities has negative effects on initiatives and hampers the overall reach and results produced by both
- Industry-led programmes often targeting a limited pool of STEM graduates are less likely to appeal to other disciplines, and demographics
- Strict division of labour between the ministries of defence and education can limit accountability and coordinated action to support defence-related skills

At the same time, the skills programmes do not exist in isolation; there are a number of external factors, both positive and negative that shape the skills supply landscape and influence the success of education and training programmes. Selected threats and opportunities are presented in Box 4.3 below.

Box 4.3 External factors that may influence the success of skills initiatives – threats and opportunities

Identified and potential threats to EDTIB's skills initiatives

- Excessive emphasis on short term needs and planning may result in the design and funding of programmes that are misaligned with long-term defence capability requirements and that do not enable industry to respond to needs of national defence establishments
- Lack of sufficient planning and foresight may lead to an inability to foster in a timely manner skills required to tackle new and emerging technologies and their use in the context of defence
- Emphasis placed by existing programmes on a restricted target group (i.e. STEM graduates) and the limited appeal that careers in the defence sector still have in a number of European countries may result in an industry-wide inability to foster and sustain the required volume of skills diversity
- Lack of regular and systematic information gathering on defence-related skills gaps and mismatches could limit awareness on gaps and mismatches, which could lead to misalignment between demand and supply of skills
- Regulatory burden such as stringent citizenship regulations, security clearance rules and entry requirements can constrain recruitment
- Reduced availability of funding and competing funding priorities in an environment of ambivalence towards the defence industry could limit resources for programmes

Opportunities available to EDTIB's skills initiatives

- Many of the above-mentioned threats could be mitigated by the European Defence Fund (EDF), via supporting investment in defence R&T and showing a longer-term interest and support for innovation in defence. Once the EDF is fully implemented, the EU will allocate a total of approximately €13 billion towards support for collaborative defence research and development within the timeframe of 2021-2027, opening greater opportunities for the defence industry.

- Defence and the importance of achieving strategic autonomy have returned at the forefront of policymakers agenda, opening a historic window of opportunity that could enable defence establishments and defence industry to receive more funding and/or policy focus from governments
- There is space for industry to take a leading role facilitating pooling and sharing of resources, ensuring better coordination, as well as the transferring of knowledge across different stakeholder groups at the regional, national and transnational levels
- Skills landscape can be enriched by improving government, industry and academia coordination to share resources, curb duplication of efforts, ensure that demand and supply of skills are aligned and achieve economies of scale otherwise untenable through stove-piping
- Broadening the range of programmes for mid-career and continuous development may improve retention and sustainability of defence industrial skills
- Building new or reinforcing existing communities of practice and skills hubs would accelerate knowledge transfer, networking and multi-stakeholder cooperation in support of defence-related skills
- Events such as defence career days, hackathons could support awareness raising for programmes
- More effective use of policy levers to support the transition of veterans and other defence personnel into the private sector could support the growth of the defence-related skills pool
- Growth of centres of excellence in emerging technologies could enhance the supply of dual-use engineering skills, which could be leveraged by the defence industry
- Exploiting more consistently IT, new and emerging technologies for skills supply initiatives

Deriving from the SWOT analysis above, a number of good practices have been identified amongst both top-down and bottom-up initiatives. Based on the examination of the array of defence-related top-down skills initiatives, the project team has identified examples of good practice (Table 4.5). The examples represent collaborative efforts aimed at fostering links between government agencies (as ultimate arbiters of defence capability requirements and thus skills needs), education institutions (as primary providers of required skills), and defence industry (as employers). Such cooperation between the key stakeholders and actors in the defence skills ‘market’ helps build a defence skills ‘ecosystem’ by improving the alignment between knowledge and skills acquired in education, employers’ requirements, and governments’ views on future defence capability needs.

Table 4.6 below presents selected examples of industry approaches to skills development and sustainment. Specifically, the models of skills provision outlined include cooperation between two suppliers on a particular defence programme to develop specific skills needed by both, internal company skills development programme adapted to each level of seniority and defence-specialisation, and the design of a specialised learning environment to foster interaction with and adoption of new and emerging technologies.

Table 4.5 Examples of good practice of top-down skills initiatives






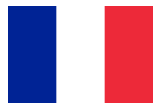



Programme	Country	Career stage	Domain	Skills focus and description of good practice
Kymeenlaakso University and Metropolia University Cyber security courses	 Finland	Early-stage and mid-career professionals	Cyber	Designed through partnership between Finnish public education institutions, programmes focus on cyber skills cyber security, such as defence and offensive, cyber security business and networks.
DAM's training programmes	 France	Early and mid-career professionals	Complex weapons	French Alternative Energies and Atomic Energy Commission (CEA)'s Military Applications Division (DAM) is involved in the nuclear deterrence industrial space, in particular in project management. DAM's internal recruitment and a steady supply of qualified candidates for the national industrial base.
Technical Munich University dual-use programmes	 Germany	Early career	Cross-domain	The common dual-degree structure of learning in industry-led programmes that combine academic education with on-the-job training can support the seamless integration of learners into the industry workforce effectively than traditional classroom based learning. The programmes cover a wide range of skills: aerospace engineering, automotive and combustion engine technology, chemical engineering, computational mechanics, information systems, and many others.
DGP Apprenticeship in Advanced Systems Engineering (SEMAP)	 UK	Early-stage and mid-career professionals	Cross-domain	A programme aimed at systems engineering. Defence Growth Partnership (DGP) is an example of good practice government-industry cooperation that works together to identify critical defence skills and generate specific programmes to close existing and future gaps.

Table 4.6 Examples of effective industry approaches to skills development and sustainment

Programme	Country	Career stage	Domain	Skills focus
Lockheed Martin and MyDefence Communication	 Denmark	Mid-career in-service professionals	Air	An agreement between two companies fosters cooperation and knowledge sharing as they will be working together to pair unmanned system with KNOX Counter-UAS system. Skills involve: expertise on rapid response aerial surveillance capabilities, integration and sustainment of advanced technology systems, industrial electrical engineering
Safran’s factory of the future concept	 France	Early and mid-career professionals	Cross-domain	Launched in 2018, the programme identified priority areas in digital transformation: virtual reality, augmented reality, robotics, additive manufacturing, an others. It aims to bring together new and traditional elements of industrial manufacturing to leverage their combined potential for efficient production, performance and innovation.
Airbus internal skills programmes	 Spain	All career stages	Air, dual-use	Airbus has a particularly well defined approach to defence related skills. Examples include: 1) Airbus Global University Partner Programme (AGUPP) aimed at technical and soft skills, developing training courses and encouraging universities to support diversity; 2) Airbus Minds Programme, training young professionals for the aeronautical industry; and 3) numerous in-house on-boarding and upskilling training programmes
The BAE Academy of Skills and Knowledge	 UK	Mid-career in-service professionals	Cross-domain	Established to provide a specialised learning environment for BAE staff, the Academy is equipped with technology replicating that used in the company’s manufacturing facilities and engineering labs in order to continuously upskill the workforce in line with the integration of new technologies and processes into the company. The Academy also acts as a collaborative skills hub for the companies across the regional engineering and manufacturing sector with requirements for a skilled STEM workforce
The Gripen programme	 Sweden	Mid-career in-service professionals	Air, cross-domain	The Gripen programme drove regional employment growth, and established Saab’s role as a catalyst for talent development in the region. More broadly, Sweden demonstrates a good practice example of a ‘knowledge triangle’ between the government, the industry and academia, as the skills required to realise the strategic priorities of defence capabilities are supported by the industry and the education sector.

4.5. Conclusion

To sum up, the skills supply mapping presented in this chapter indicates that the defence industrial skills landscape is not uniform across EU MS. While most countries do not have national defence skills strategies, selected countries such as **France, Finland, the Netherlands and the UK** have either a defence-specific industrial strategy or other government strategy that singles out the importance of defence industry skills.

The progressive focus of EU policy on defence is raising awareness about the availability of funding to address capability, personnel and skills shortfalls within both the armed forces and the EDTIB. The added value of the European dimension allows for mobility of students and free movement of workers in the EU which, in turn, has a positive impact on transferability of skills as strengthening mobility and knowledge exchange in defence can help develop and sustain skills. In a number of countries industry-led programmes enable their beneficiaries to draw on the best of both the academic and industrial worlds by providing dual-degree programmes, such as in **Germany and Netherlands**. Dual degree programmes are the most common and also successful mechanism of integrating non-defence skills in defence education.

The industry is also mindful of the importance of acquiring, sustaining and further developing relevant skills in order to support their business and, ultimately, be able to respond to national demand supporting defence capabilities. Due to the defence-specific character of many skills that are not provided by the education sector, skills programmes carried out by the industry are particularly significant. This report identified collaborative initiatives to be amongst some of the most effective ways of identifying possible future skills gaps and addressing the challenges associated with skills mismatches. From industry clusters promoting innovation and knowledge-sharing to collaborative strategies involving the industry, government agencies and education sector, more streamlined and effective communication between key stakeholders can help address mismatches between skills provided by the education sector and the industry needs.

Finally, substantial heterogeneity in the skill landscape across countries suggests that a ‘one size fits all’ policy at a European level is not feasible. Instead, identified opportunities can be explored and capitalised upon, designing more tailored mechanisms and addressing relevant stakeholders. The next chapter discussed some of the considerations that arise from the overall analysis of supply and demand of defence industrial skills in the EDTIB and that would shape the creation of the sectoral skills strategy.

Box 4.4 Information on other relevant parts of the report

You may find more detailed information about the following topics in other parts of the report

- Detailed information on how companies and national governments measure skills development is included in Annex D Section D.3.1
- Detailed information on the reviewed upskilling initiatives is included in Annex D Section D.2.1
- Detailed description of relevant EU-level policies are included in Annex C Table C.1.
- Detailed mapping of key EU-level funding instruments is included in Annex C Table C.2
- Detailed breakdown of types of top-down and bottom-up programmes is included in Annex D

- Details of the methodology used are included in Methodology Annex
- Discussion of the transferability of industrial skills within defence domains and across defence and civilian sectors may be found in Annex B Section B.1
- A comparison with business practices in IT and high tech sectors is included in Annex B Section B.2

5. What are key considerations for developing a sectoral skills strategy?

This work presented in this report provides an overview of defence-related skills availability, gaps and shortages. The report also outlines the main characteristics of the European defence industrial skills supply, by identifying and analysing a range of existing and planned EU, national, regional, and industry-led policies, programmes and initiatives that exist to support it. This resulting landscape provides the informational basis for the next phase of the project, namely, designing pathways to address the identified mismatches in the next stage of the project and developing a sectoral skills strategy for defence. The purpose of this chapter, therefore, is to draw out the implications of the current state-of-play for the future strategy, outlining which considerations it must take into account.

European defence industry and defence policymakers are finding themselves faced with an important **window of opportunity** to strengthen their standing and position in a competitive global market. In light of shifts and events within Europe's geostrategic context over the last decade, **defence, security and the importance of achieving strategic autonomy have climbed to the forefront of European policymakers' agenda**. Moreover, across EU MS, more favourable public perceptions towards the defence field could facilitate both armed forces' and industry's recruitment efforts. Finally, as Chapter 3 illustrates, there is already a widely-recognised problem with the European defence industrial skills landscape and, on the whole, industry is struggling to fill existing vacancies and to adapt dynamically to future requirements, impacting its competitiveness and, ultimately, the efficiency of capability development by national MODs and armed forces and thus the security of Europe

Given the high level of economic integration across the EU through the Single Market and the resources that the EU has at its disposal a coordinated EU-level approach to addressing sectoral skills challenges offers considerable potential. Mapping of the defence skills landscape conducted by this report serves as a first step in improving the understanding and highlighting strengths and problem areas of different approaches to skills development and sustainment. In order to maximise benefits that can be reaped from this context, there is an opportunity for defence industry, but only if enabled by EU MS governments, to take a leading role in **facilitating pooling and sharing of resources and fostering better coordination and transfer of knowledge across different stakeholder groups at the regional, national and transnational levels**.

As this project concludes the landscaping and information gathering phase, and looks ahead to the formulation of the defence sectoral skills strategy, it is important to highlight the key considerations that have emerged from this report which will shape the strategy content. Firstly, it is crucial to recognise that **'one-size-fits-all' approach will not be viable for formulating a common European approach**, as strategic

and manufacturing needs, as well as skill availability and defence equipment generation models, differ significantly across the EDTIB. Furthermore, an overarching European strategy will need to be sensitive to and pragmatic about the still fundamentally national, rather than cross-border, focus of the practices, views, and structures underpinning the defence sector. Similarly, as demonstrated in this report, a wide range of instruments, tools, and programmes already exist at the national and European levels to help industry address its skills challenges, but it is important to ensure that these **mechanisms are adapted for use by industrial actors**, which includes large firms as well as SMEs, and this may mean that administrative and bureaucratic requirements associated funding instruments need to be streamlined accordingly.

In addition, rather than suggesting individual programmes or specific skills which ought to be prioritised, a European-level strategic approach to addressing skills gaps will need to focus on **strengthening and adapting the enabling structures** which will support industry, public authorities, and education and training organisation in formulating their own skills development and sustainment initiatives, both unilaterally and cooperatively. In fact, this report has demonstrated that there is a significant margin for **improving resource coordination between defence industry stakeholders, public authorities and academia**. Coordination with national governments and public authorities more broadly should aim to channel efforts and resources in a manner that ensures a more thorough coverage of all existing and emerging skills requirements. Increased cooperation amongst the industry in non-sensitive areas for which individually companies do not have large amount of funding (radar, sensors), but also new technologies to drive innovation, can help stretch existing resources further and maximise the return on investment in specialised skills. Involving academia in the dialogue would also help the government and industry to translate strategic medium- and long-term skills priorities into education programmes.

Thus, to help skills sustainment, development and cross-pollination, formalised or regularised **programmes for exchanging technical staff and experts** across government and industry, throughout defence industry, and between the defence and civil industry, could be considered. This effort could build on the already existing practices of, in particular, large OEMs and system integrators, which transfer talent across their countries of operations and also between their defence and civil businesses, but would be widened to encompass other stakeholders and SMEs. Such an initiative could also **have important benefits for SMEs**, many of which may lack visibility of the relevant defence programmes, funding mechanisms and skills initiatives open to them, and the influence to help shape their development. Supported by the European Commission, **the EDSP, bringing together representation from the MS, the industry, and academia, could play an important role** in trailblazing such an effort and sharing good practice and lessons learned. Due to its wide-ranging expert and stakeholder membership, regular engagement with the EDSP could also help government and industry better anticipate relevant future shifts in skills demand arising from technological developments.

In this regard, several **mechanisms, structures, and funding instruments aimed at enabling and incentivising European collaboration in defence capability development** have emerged in recent years and can be leveraged to better incorporate skills development and institute systems and processes for knowledge exchange in the context of collaborative programmes and approaches. These structures include PESCO, the Coordinated Annual Review on Defence process, and EDF; with the Fund incentivising collaborative programmes, and PESCO and CARD structures and monitoring mechanisms ensuring the

incorporation of skills development and exchange aspects into programme design. For instance, to foster greater consolidation and a more streamlined approach to knowledge transfer at a programme level, attention could be paid to enabling cross-border mobility of key technical staff on collaborative projects. Of course, the effectiveness of these efforts is predicated on the commitment of national MODs to smoothing out the defence equipment demand cycle and avoiding the 'boom and bust' pattern of defence capability investment that can deplete the skills base and dis-incentivise industry investment in the sustainment of specialised skills.

This report has also highlighted the **close linkages between the defence and civil sectors and between defence and commercial industries**, with the majority of defence industrial players being active in the civil domain, a number of key enabling technologies having both military and commercial applications, and both defence and commercial employers relying on a common labour pool for the talent they require. Importantly, it is also the civil sector that has emerged as the driver of innovation. For these reasons, a truly agile and competitive defence skills base that delivers Europe's future capability needs will require closer integration of defence and civil skills and cooperation between stakeholders from defence and commercial sectors. A European defence sectors skills strategy will therefore need to address the barriers to such cooperation and cross-pollination and suggest ways of enabling and improving it.

A final theme that emerges from this report and will be important to tackle in the context of a European strategy, is the need to promote a **more appealing image of defence industry** as an employer to **broaden the diversity of the defence skills base**. By unpacking some of the reasons behind recruitment difficulties, the industry, academia, and other national and EU-level stakeholders could work together to address these challenges with awareness-raising workshops, targeted seminars, roadshows and other initiatives. While working on improving perceptions of the defence industry, the European defence community can also work on a broader outreach outside the 'traditional' pool of candidates. Broadening the talent pool to include more female and non-STEM graduates, for example, would increase the diversity and, ultimately, the breadth and resilience of the defence skills base, as well as ensuring that a range of different perspectives were brought to the sorts of technical and design problems that companies face day-to-day, leading to more creative solutions.

Abbreviations

AGUPP	Airbus Global University Partner Programme
AI	Artificial Intelligence
AIAD	Federazione Aziende Italiane per l'Aerospazio, la Difesa e la Sicurezza
AR	Augmented Reality
AT	Austria
BCG	Boston Consulting Group
BE	Belgium
BMWI	Federal Ministry of Economics and Technology
BNP	Bruttonationalprodukt
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CARD	Coordinated Annual Review of Defence
CBRN	Chemical, Biological, Radiological and Nuclear
CDP	Capability Development Plan
CEA	Alternative Energies and Atomic Energy Commission
CEDEFOP	European Centre for the Development of Vocational Training
CEE	Central and Eastern Europe
CEF	Connecting Europe Facility
CenSec	Center for Defence, Space and Security in Denmark
CODABA	Collaborative Database
COMINT	Communications Intelligence
COSME	Competitiveness of Enterprises and Small and Medium-sized Enterprises
CPS	Cyber-Physical Systems
CSDP	Common Security and Defence Policy

CTNA	Italian Cluster for Aerospace Technology
CZ	Czech Republic
DAM	Military Applications Division
DE	Germany
DE&S	Defence Equipment and Support
DEEP	Defence Enterprise and Export Programme
DESG	Defence Engineering and Science Group
DGA	Directorate General of Armaments
DGAM	Directorate General of Armament and Material
DGP	Defence Growth Partnership
DK	Denmark
DKK	Danish Krone
DLR	German Aerospace Center
DOTMLPF	Doctrine, organization, training, materiel, leadership and education, personnel, and facilities
DOD	Department of Defense
Dstl	Defence Science and Technology Laboratory
DTIB	Defence Technological Industrial Base
DTUS	Defence Technical Undergraduate Scheme
EADS	European Aeronautical Defence and Space
EASME	Executive Agency for Small and Medium-sized Enterprises
EC	European Commission
EDA	European Defence Agency
EDAP	European Defence Action Plan
EDF	European Defence Fund
EDIDP	European Defence Industrial Development Programme
EDSP	European Defence Skills Partnership
EDTIB	European Defence Technological Industrial Base
EE	Estonia
EIB	European Investment Bank
EIF	European Investment Fund

EII	European Intervention Initiative
ENDR	European Network of Defence-related Regions
ERASMUS	European Region Action Scheme for the Mobility of University Students
ES	Spain
ESA	European Space Agency
ESF	European Social Fund
ESIF	European Structural and Investment Funds
EU	European Union
EUR	Euro
FAD	Defense & Aerospace Industries Association in Denmark
FCAS	Future Combat Air System
FI	Finland
FR	France
GDELS	General Dynamics European Land Systems
GDP	Gross Domestic Product
GIFAS	Groupement des Industries Françaises Aéronautiques et Spatiales
GTS	Advanced Technology Group
ICT	Information Communications Technology
IHEDN	Institut des Hautes Etudes de Défense Nationale
IM	Insensitive Munitions
INI	National Industry Institute
ISR	Intelligence, Surveillance, Reconnaissance
IT	Information Technology
IT	Italy
ITS	Higher Technical Institutes
JEF	Joint Expeditionary Force
KMW	Krauss-Maffei Wegmann
LIFE	Programme for the Environment and Climate Action
LRN	Lucht en Ruimtevaart Nederland
LT	Lithuania
LV	Latvia

MA	Master of Arts
MALE	Medium Altitude Long Endurance
MARIN	Maritime Research Institute of the Netherlands
MBT	Main Battle Tank
MEA	Ministry of Economic Affairs
MOD	Ministry of Defence
MOOC	Massive Online Open Courses
MPL	Military Planning Law
MRO	Maintenance, Repair and Operations
MRTT	Multi Role Tanker Transport
MS	Member State
NAG	Netherlands Aerospace Group
NATO	North Atlantic Treaty Organisation
NL	Netherlands
NLR	National Aerospace Laboratory
NIDV	Netherlands Industries for Defence and Security
NORDEFECO	Nordic Defence Cooperation
OECD	Organisation for Economic Cooperation and Development
OEM	Original Equipment Manufacturer
OMT	Odense Maritime Technology
OSS	Odense Steel Shipyard
PADR	Preparatory Action on Defence Research
PESCO	Permanent Structured Cooperation
PGZ	Polska Grupa Zbrojeniowa
PL	Poland
RPAS	Remotely Piloted Aircraft Systems
SALW	Small Arms and Light Weapons
SC	Steering Committee
SE	Smartare Elektroniksystem
SE	Sweden
SEMAP	Defence Apprenticeship in Advanced Systems Engineering

SI	Smart Industry
SME	Small and Medium-sized Enterprise
SOFF	Swedish Security & Defence Association
SQEP	Suitably Qualified and Experienced Person
SSH	Secure Shell
STC	Supplemental Type Certificate
STEM	Science, Technology Engineering and Maths
SWOT	Strengths, Weaknesses, Opportunities and Threats
TEC	Technical Education Copenhagen
TFEU	Treaty on the Functioning of the European Union
TKMS	ThyssenKrupp Marine Systems
TLVS	Taktisches Luftverteidigungssystem
TNO	Netherlands Organisation for Applied Scientific Research
UAS	Unmanned Aircraft System
UN	United Nations
US	United States
UK	United Kingdom
VR	Virtual Reality

Annex A. Analysis of survey results

This annex accompanies Chapter 3 and presents the **analysis of the survey data** provided European stakeholders active in defence for the purposes of this project, with the majority of respondents being defence industry. This analysis identifies existing mismatches in skills relevant for the EU defence technological and industrial base (EDTIB), their impact on the defence industrial base and the reported reasons for their existence. The principal findings of the survey data analysis are summarised in Box A.1.

Box A.1 Summary of survey data analysis

- The survey aims to identify skills mismatches as perceived by defence employers in order to articulate the nature of the ‘problem’
- The data underpinning the analysis of skills mismatches was supplied by 81 stakeholder organisations across the EU, providing a diverse set of perspectives on the European defence skills landscape
- Survey evidence on skills mismatches provides a nuanced picture, with a high occurrence of external skills shortages, indicating difficulty to source the right skills from the wider labour market
- The perceived reasons for skills mismatches vary by uniqueness to defence, with less specialised skills reportedly difficult to attract due to wage competition and lower attractiveness of defence
- There is an overlap between current and near-term skills mismatches, indicating a potential chronic difficulty in sourcing and retaining skills
- Skills mismatches are also found in individual defence domains, which may be difficult to source given the limited pool of talent
- For domain specific skills, low defence demand and demographic challenges are perceived to be key drivers of skills mismatches due to the high risk of skills atrophy
- When considering the urgency of mismatches, SMEs face immediate challenges with project management and test engineering skills, which could hamper their ability to deliver projects effectively
- While larger companies perceive insufficient defence demand to be as important as competition for talent with other sectors, for SMEs, competition for talent is one of the principal concerns
- Skills mismatches can have impact on the EDTIB, potentially undermining companies’ competitiveness and ability to innovate
- To keep pace with new technologies and to drive future innovation, the EDTIB will have to address additional skills challenges

Source: RAND Europe analysis

A.1. The survey aims to identify skills mismatches as perceived by defence employers in order to articulate the nature of the ‘problem’

In order to articulate the nature of the ‘problem’ in relation to defence skills, that is, the issues that are being addressed by the EU-level defence skills strategy, it is necessary to look at the best available relevant

data on skills. More specifically, what needs to be better understood is whether there are any challenges in ‘matching’ the demand for defence-related skills (see Chapter 3) with the skills trained in the education sector and/or provided by other industries, the military or civil employers (i.e. the supply of skills). As such, the focus needs to be on identifying whether there are any skills ‘mismatches’ and if so, what the nature and cause of these may be across the different groups of skills (e.g. design, engineering, manufacture, maintenance) and across different defence domain (e.g. air, naval, land, space).

From a methodological point of view, there is a need to be specific about the concepts of interest when analysing skills mismatches.¹¹² Within this project, two main types of skills mismatches are examined:

- **Skills shortages**, referring to a “situation in the labour market where the demand for particular type of skills is higher than the supply of workers with that type of skill”¹¹³
- **Skills gaps**, referring to a “situation where the type of skills of people do not match the requirements of the job or the level of skills is less than the level required to perform the tasks associated with the job satisfactorily”¹¹⁴

A.2. Skills shortages

Skill shortages might arise, amongst other things, due to technological and demographic change such that there may be substantial qualitative changes in the demand for skills over the medium-term. In practice, skill shortages prove difficult to measure and quantify. Differential occupational wage growth has been used to identify those jobs where demand exceeds supply. In many countries there are various wage rigidities in place that might lead one to question the extent to which differential wage growth actually gives an accurate assessment of skill shortages over the short- to medium-term.

An alternative approach is to assess skill shortages through the use of surveys – a methodology employed within this project. In employer surveys, a distinction is usually made between external and internal skill shortages.¹¹⁵ The former refers to recruitment from the external labour market. Employers will be asked, for example, if their firms have vacancies, whether the vacancies relating to a particular job are proving hard-to-fill. This then provides a measure of external skill shortages. Within the survey deployed for this project, respondents were asked whether they had difficulties filling in vacancies for specific skills groups in the last 12 months. As such, external shortages are distinguished from internal shortages, where this information was provided.

¹¹² Green, Jonathan. 2018. 'Modernising Defence Programme: Submission by Prospect to the Ministry of Defence'. *Prospect*. As of 24th December 2018: <https://library.prospect.org.uk/download/2018/00802>

¹¹³ Skills Panorama. 2018b. 'Shortage (skills shortage).' As of 12 November: <https://skillspanorama.cedefop.europa.eu/en/content/shortage-skills-shortage>

¹¹⁴ Skills Panorama. 2018a. 'Gap (skills gap).' As of 12 November: <https://skillspanorama.cedefop.europa.eu/en/content/gap-skills-gap>

¹¹⁵ Hogarth, Terence. 2016. 'Designing an employer skills survey'. *Inter-American Development Bank*. As of 21st December 2018: <https://webimages.iadb.org/publications/english/document/Designing-an-Employer-Skills-Survey-Notes-on-How-to-Develop-a-Survey-to-Meet-a-Range-of-Policy-Issues-Relating-to-the-Demand-for-and-the-Supply-of-Skills.pdf>

A.3. Skills gaps

Skills gaps arise when there is a gap between the level of skills required to perform the job/task satisfactorily and the existing skills level. Within an employer organisation, an internal skills gaps refers to a situation where the existing skills of the workforce are insufficient to fulfil the workplace's product market strategy and thus hinder its ability to meet their delivery requirements. Research has shown that there is an inverted U-shaped relationship between internal skills gaps and organisational performance: companies in decline struggle to retain key personnel and their skills and report internal shortages, while companies performing at the cutting-edge have growing skills demands (e.g. due to embedding new technologies) that are difficult to satisfy and thus also report relatively high levels of skills gaps.¹¹⁶ To reflect this two-fold dimension of skills gaps, the survey deployed for this project focused on both skills that are currently needed for a competitive EDTIB and those that will be required in the near future as a result of technological advances in fields like artificial intelligence, big data processing and analytics, robotics and automation and others. As such, internal skills gaps are reported both in relation to the current skills requirements and those foreseen in the next 5-10 years.

The data underpinning the analysis of skills mismatches was supplied by 81 stakeholder organisations across the EU, providing a diverse set of perspectives on the European defence skills landscape

One of the core parts of this ongoing project consists of running an EU-wide survey of defence organisations with knowledge of skills relevant for the EDTIB in order to identify the following:

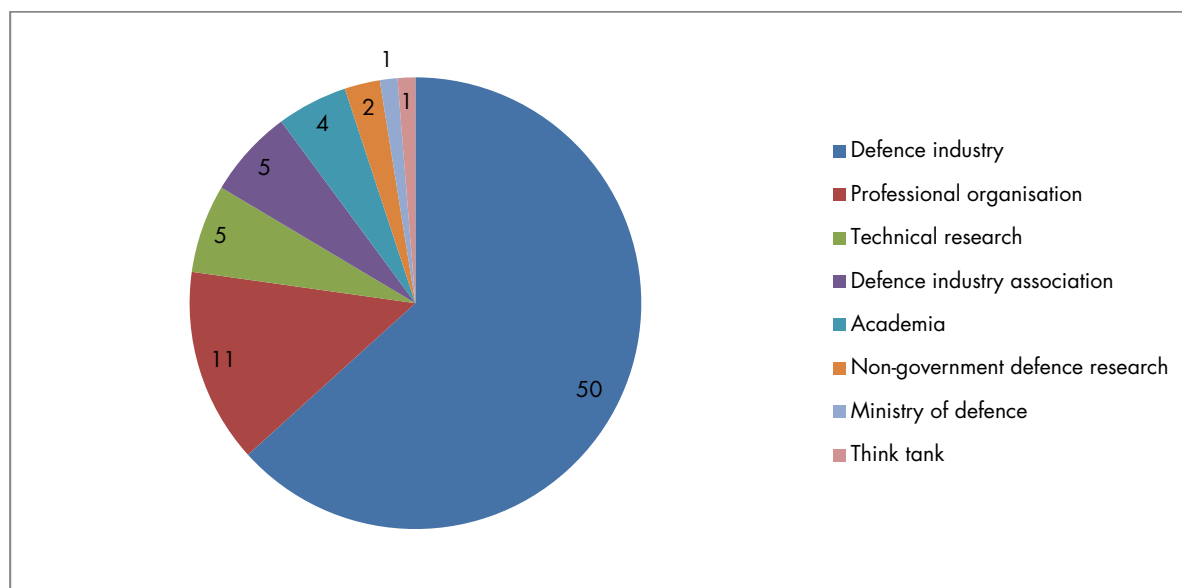
- The extent to which EU defence industry stakeholders perceive there are skills mismatches in skills required to design, manufacture and maintain defence equipment;
- The extent to which EU defence industry stakeholders perceive skills mismatches likely to occur in the future (next 5 and next 10 years);
- Skills that are relevant across the EDTIB and are seen by survey respondents as challenging to attract or retain or both;
- Skills that are relevant for specific defence domains which are seen by survey respondents as challenging to attract or retain or both;
- The perceived principal reasons for existing skills gaps and their implications.

A total of 81 organisations have submitted survey answers, representing a wide range of different defence organisations in terms of organisation type, size, as well as geographical location (see Figure A.1 and **Error! Reference source not found.**). The study team gathered these responses during the period between July and October 2018 using an online survey. Please refer to the *Methodologies Annex* for further information on how the survey was designed, disseminated and analysed. The survey focused on technical skills in design, engineering, manufacturing, maintenance, in-service support and disposal related to defence equipment and defence industry. The full suite of these skills is set out in the taxonomy of skills

¹¹⁶ Hogarth, Terence and Robert Wilson. 2002. 'Secondary Analysis of Employers Skill Survey 2001'. *Institute for Employment Research, University of Warwick*. As of 21st December 2018: https://warwick.ac.uk/fac/soc/ier/publications/2001/hogarth_and_wilson_2001_synthesis.pdf

included in *Methodologies Annex C*, which forms the basis of the data collection. As explained in Chapter 3, the taxonomy of skills provides a structured list of skills that are currently required across the EDTIB to design, deliver and maintain defence equipment. As noted in Chapter 2, the proxies for identifying which skills are required in which country are the following: (a) defence equipment that is currently in use by different EU Member States, (b) equipment that is being procured (developed domestically or procured off-the-shelf); (c) equipment for export (d) as well as equipment that is planned for the future and may or may not be already on contract.

Figure A.1 Survey respondents by organisation type



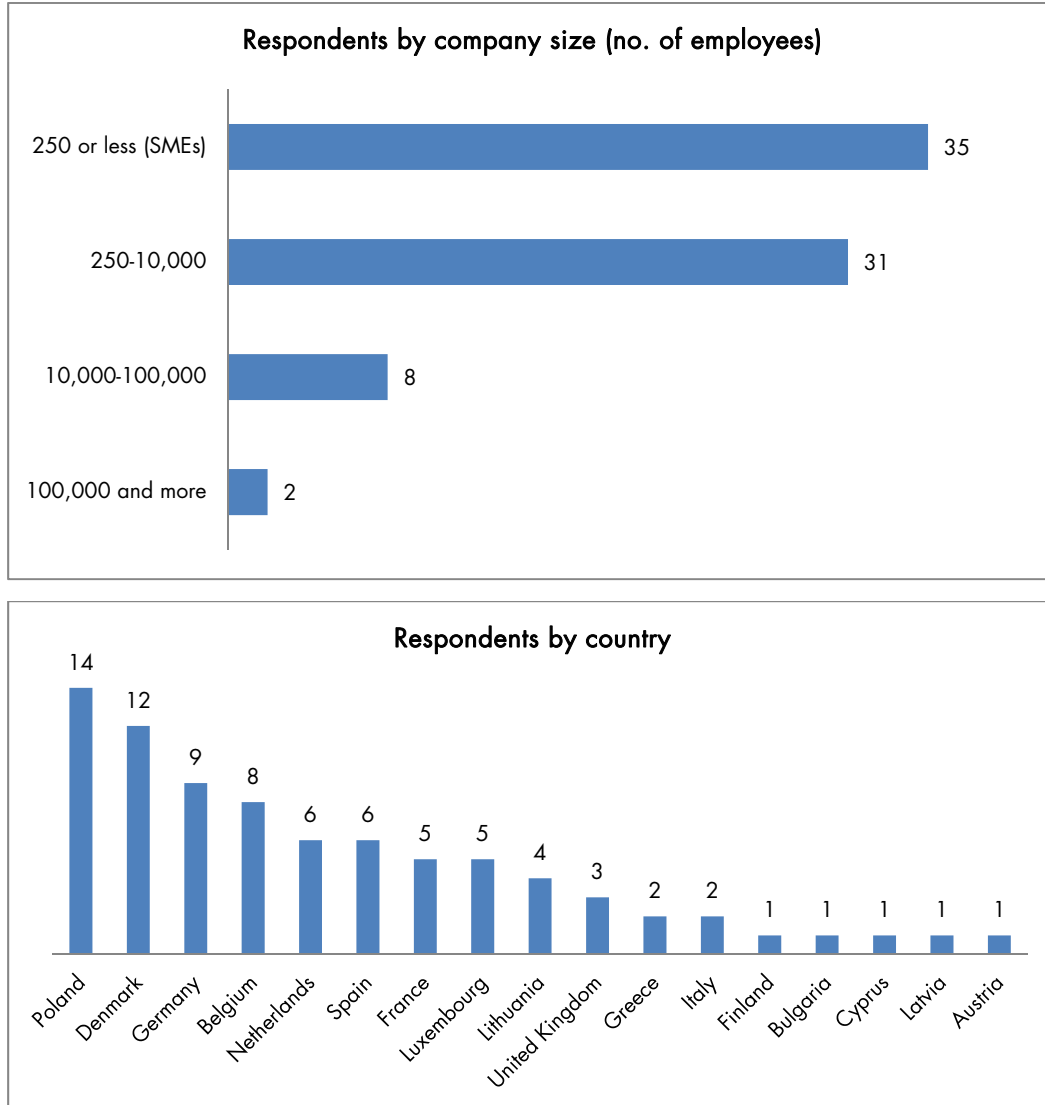
Source: RAND Europe analysis

As shown in **Error! Reference source not found.**, the respondent sample covers a range of different types of companies, ranging from small and medium sized enterprises to primes. Respondents also represent a geographically dispersed sample, as shown in the list of respondent countries ranked by highest number of responses. As per the objectives of this project, which emphasise the need to consider the EU-wide defence industrial base, the survey was widely disseminated to defence primes, tier I, tier II and tier III suppliers, with the aim to capture as broad a range of responses as possible. In contrast with the 2015 study on key skills in defence¹¹⁷ which relied heavily on information provided by systems integrators (primes) across half a dozen countries, this project is able to draw on a much broader evidence base which, crucially, includes SMEs and other lower tier suppliers across 17 different EU countries. The highest number of respondents represent small and medium sized enterprises with fewer than 250 employees, followed by a tier II supplier group with 250-10,000 employees, followed by defence primes with over 10,000 employees and large industry associations with more than 100,000 employees combined from

¹¹⁷ Retter, Lucia, Louise Taggart, and Jon Freeman. 2015. *Key Skills and Competences for Defence: Annex E*, European Defence Agency, RR-1226-EDA. As of September 26, 2018: https://www.rand.org/pubs/research_reports/RR1226.html

across their member organisations. Based on the employment numbers of the respondent organisations, this survey covered around 675,000 employees.

Figure A.2 Responses by organisation size and country (where reported)



Source: RAND Europe analysis

The survey did not ask about supporting functions and skills required therein such as human resources, IT, legal, finance and other administrative functions as these can often be transferred from the civil sector and adapted to defence through additional learning and understanding of the defence context. Depending on the issue at hand, this additional learning and adaptation to the context may be substantial such as, for example, in relation to the knowledge and understanding of defence export regulations in general and ITAR in particular. However, the fundamental legal and commercial skills, including the ability to conduct legal analysis and having an understanding of regulatory systems and their implementation and implications for contracting are arguably the same, with the key differences relating to the subject matter (i.e. defence).

The survey also did not ask about ‘soft skills’ such as inter-cultural understanding or foreign language fluency – although these, too, are necessary for a functioning and efficient EDTIB. However, respondents had a free-text option to highlight any additional skills where they perceive skills mismatches and have highlighted several ‘soft skills’ where they perceive inadequate skills levels. These included:

- Ability to work in teams
- Leadership skills
- Critical thinking skills
- Cultural awareness
- Resilience

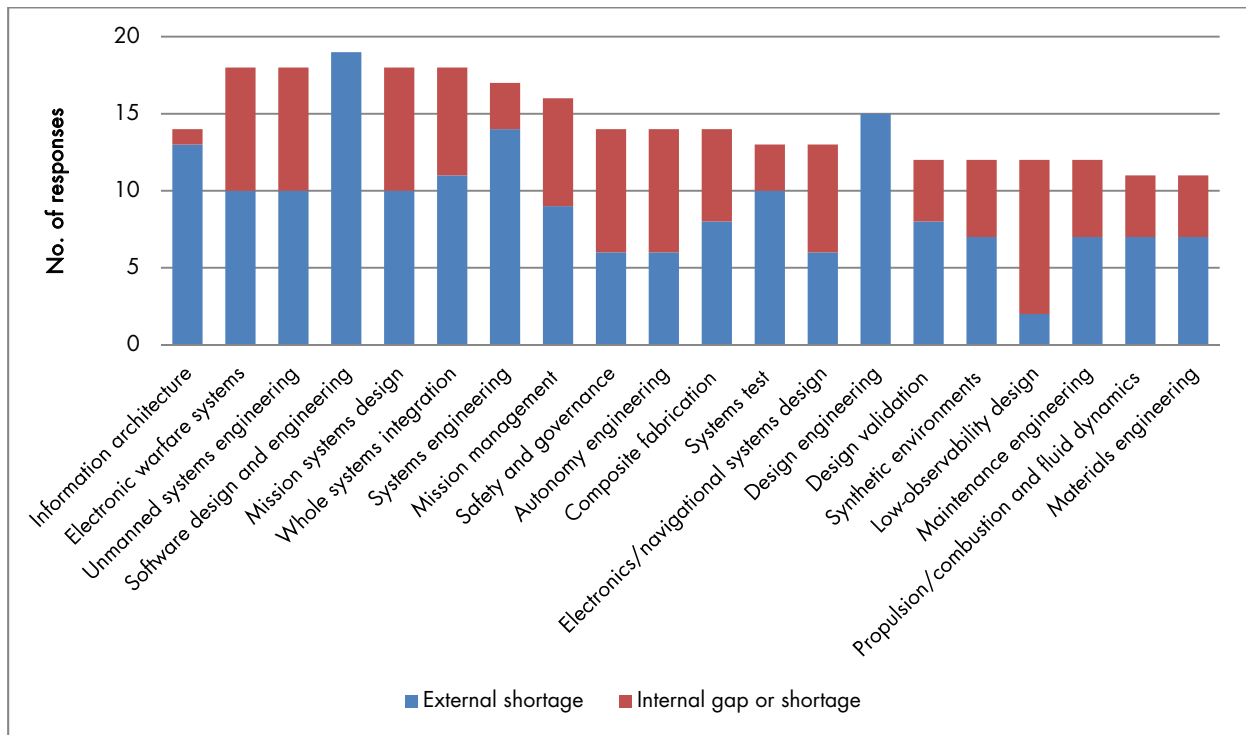
While the survey was designed to quantify the presence of skills mismatches (e.g. the number of respondents reporting shortages in certain skills groups), qualitative dimensions are also important to consider. There may be sufficient quantitative supply for a skill or job, but the quality of that supply may not meet employers’ requirements. Equally, skills may be present in the company already but are at an early stage of learning and hence not at full productivity level. This becomes an acute challenge with skills that are highly specialist to defence and can be developed through internal on-the-job training only. Finally, there may be sufficient skills now but due to upcoming retirement and loss of expertise, transfer of skills and knowledge may create a skills gap in the medium term. Bearing all this in mind, in assessing the level of skills shortages or skills gaps, there is a need to piece together data from a variety of sources, including interviews, surveys and available literature to develop a narrative about the way in which skills are required by the EDTIB and the way in which they can be matched by the supply provision. The survey data presented here thus provides one of several pieces of the jigsaw puzzle and should be viewed in that context.

Survey evidence on skills mismatches provides a nuanced picture, with a high occurrence of external skills shortages, indicating difficulty to source the right skills from the wider labour market

The first part of the survey asked respondents to identify those occupation areas where they are currently facing skills requirements they are unable to fill or else face significant challenges in doing so. **72% of respondents (58 out of 81) identified skills mismatches in technical defence skills.** Figure A.3 shows most frequently reported mismatches, where more than 20% of respondents reported a skills mismatch. No significant difference has been detected between different types of companies (SMEs, tier II and III and primes).

To understand the type of ‘mismatch’, further questions were asked in the survey to elicit responses as to whether the mismatch related to inability to fill in vacancies in the last 12 months. If this was the case, the mismatch was identified as an external shortage. Where external supply was not identified as a challenge, skills mismatches were classified as internal.

Figure A.3 Reported skills gaps and mismatches – technical defence skills



Source: RAND Europe analysis of survey data

As Figure A.3 shows, external skills shortages (indicated by reported recent vacancies which were difficult to fill) represent a large portion of the most frequently reported mismatches in technical defence skills. In addition to the technical skills, further skills mismatches were also reported in relation to management and support skills, namely: project management, cost estimation and procurement. For these, about half of the respondents reported particular challenges in sourcing these skills in a timely manner to meet the demands of ongoing and future defence programmes.

Based on the internal expert assessment, drawing on the initial assessment conducted for the 2015 study on key skills and competences for defence, the project team identified which skills with reported mismatches are highly specialised to defence and which have a lower degree of specialisation and are thus more easily transferrable from other sectors.

Skills areas that are critical for achieving military advantage such as electronic warfare systems design and engineering, mission systems design, mission management and low-observability design and engineering are highly specialised to defence. It is very difficult, if not impossible, to source them directly from the external labour market. The results shown in **Error! Reference source not found.** confirm this, depicting these skills areas as the ones with greatest proportion of internal (rather than external) skills gaps. As such, the survey data confirms that highly unique skills to defence are difficult to source externally and need to be developed in house (e.g. through internal training programmes, mentoring, knowledge transfer initiatives and others).

For most of the other skills areas with reported mismatches, it seems that these mismatches are a combination of external and internal gaps; in other words, a combination of insufficient skills levels to meet the required ‘quality’ of the skill (i.e. skills *gaps*) and insufficient supply of these skills on the wider

labour market (i.e. external skills *shortages*). For a few skills areas with low level of specialisation to defence, reported mismatches are primarily external, namely: software engineering, design engineering and systems engineering. As shown in **Error! Reference source not found.** these are not unique to defence and hence defence industries are likely to compete for these skills on a wider labour market.

Table A.1 Reported mismatches by uniqueness to defence

Skills area and specialisation to defence	
1. Information architecture	M/H
2. Electronic warfare systems design and engineering	H
3. Mission systems design	H
4. Whole systems integration engineering	M/H
5. Software design and engineering	M
6. Unmanned system engineering	M/H
7. Systems engineering	M
8. Mission management (concept, design, development and integration)	H
9. Autonomy engineering	M
10. Composite fabrication engineering	M
11. Safety and governance management	M/H
12. Electronics/navigational systems design	M/H
13. Systems test engineering	M
14. Design engineering	M/H
15. Low observability design and engineering	H
16. Synthetic environments design and engineering	M/H
17. Design validation	M/H
18. Maintenance engineering	L
19. Propulsion, combustion and fluid dynamics	M
20. Materials engineering	M

Source: RAND Europe analysis. Key: **H**- high specialisation to defence, **M/H**- medium/high specialisation to defence; **M**- medium level of specialisation to defence, **L**- low level of specialisation to defence

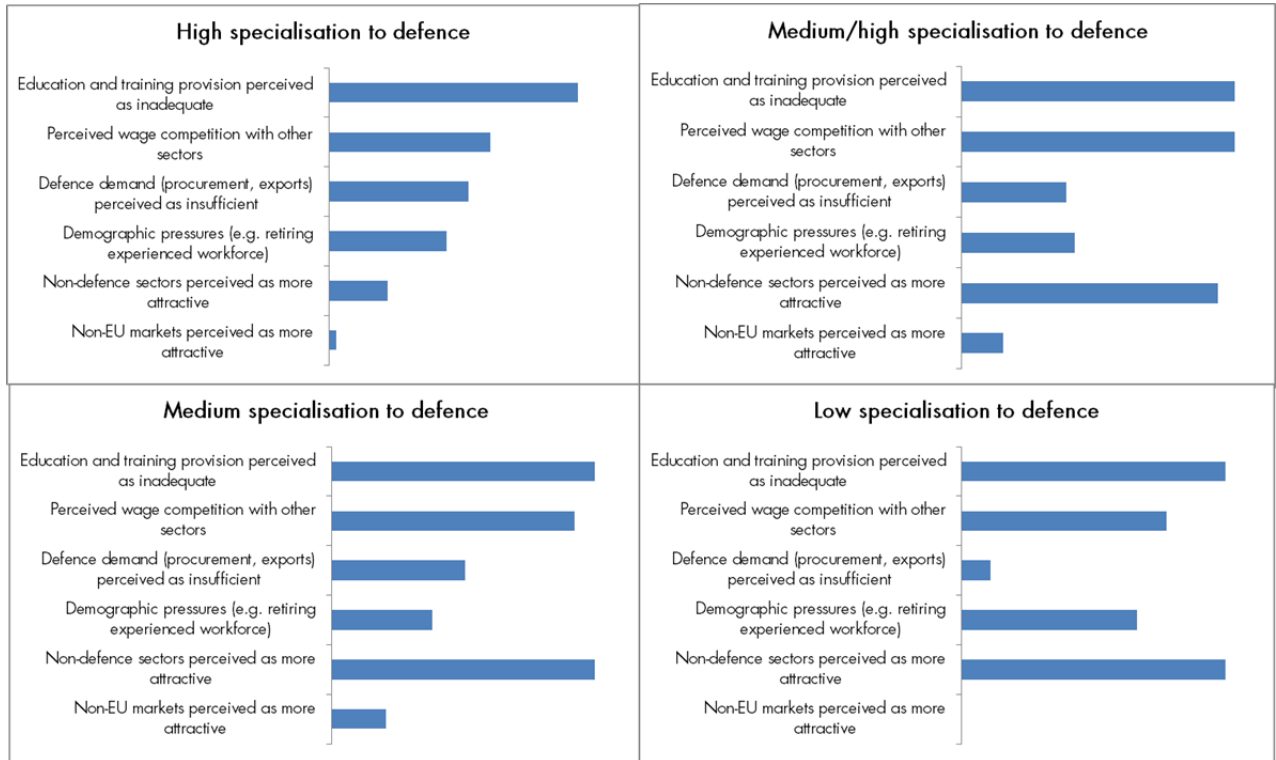
The perceived reasons for skills mismatches vary by uniqueness to defence, with less specialised skills reportedly difficult to attract due to wage competition and lower attractiveness of defence

As shown in **Error! Reference source not found.** , different factors are perceived to drive skills mismatches for technical defence skills at various levels of defence specialisation. The data on perceived reasons behind the skills mismatches allows for several observations to be made:

- The most frequently reported perceived reasons for skills mismatches in skills that are highly specialist to defence (such as electronic warfare engineering, mission management and low observability design engineering) were: inadequate education and training provision to build and nurture these skills, wage competition with other defence and non-defence companies, insufficient defence demand (i.e. procurement and exports) and demographic pressures of retiring expert workforce that will be difficult to replace
- For medium-high level of specialisation to defence, the following reasons were perceived to drive the skills mismatches: wage competition, perceived inadequate education and training provision and defence being seen as a less attractive sector. Demographics and insufficient defence demand were perceived as slightly less prominent although still important factors.

- For medium and low level of defence specialisation, the same holds true as for medium-high level of defence specialisation, with slightly less importance being placed on demographics as a perceived driver of skills mismatches.

Figure A.4 Perceived reasons behind skills mismatches in the top 20 technical defence skills



Note: The bars indicated the frequency of reported reasons for skills mismatches.

Source: RAND Europe analysis

A reported mismatch between skills supplied by educational and training institutions and employer needs is a common phenomenon identified in studies on skills mismatches.¹¹⁸ While it may be the case that some mismatches exist for skills with low to medium level specialisation to defence, with graduate level courses not aligned with industry needs; skills that are specialist to defence (e.g. those in

¹¹⁸ See for example: Employers Skills Survey UK (2017); European Commission. 2017d. ‘Blueprint for Sectoral Cooperation on Skills: Responding to Skills Mismatches at Sectoral Level.’ As of 28 September 2018: <http://ec.europa.eu/social/main.jsp?catId=1415&langId=en>

Table 4.1) are certainly not supplied into defence industry from most graduate level education institutions. Rather, they may be developed through specialised training schemes, targeted postgraduate courses and, most frequently, within the company (through internal training programmes or less formalised mentoring schemes). The mismatches between training provision and employer needs for specialised defence skills are likely to refer to an insufficient offer of relevant specialised (most likely small-scale) training programmes.

While there is likely to be a confluence of reasons behind skills mismatches in each of these categories, for skills that are more easily transferrable from civil sectors, wage competition and the attractiveness of defence are likely to play more determinant roles in driving skills mismatches than for highly specialised defence skills. The latter tend to be nurtured through specific defence programmes and as such tend to be dependent on defence demand and expertise in house (which is often linked to years of experience). As such, mismatches in highly specialised defence skills are likely to be driven by insufficient defence demand and demographic pressures, the combination of which may lead to erosion of some critical skills for a competitive EDTIB.

There is an overlap between current and near-term skills mismatches, indicating a potential chronic difficulty in sourcing and retaining skills

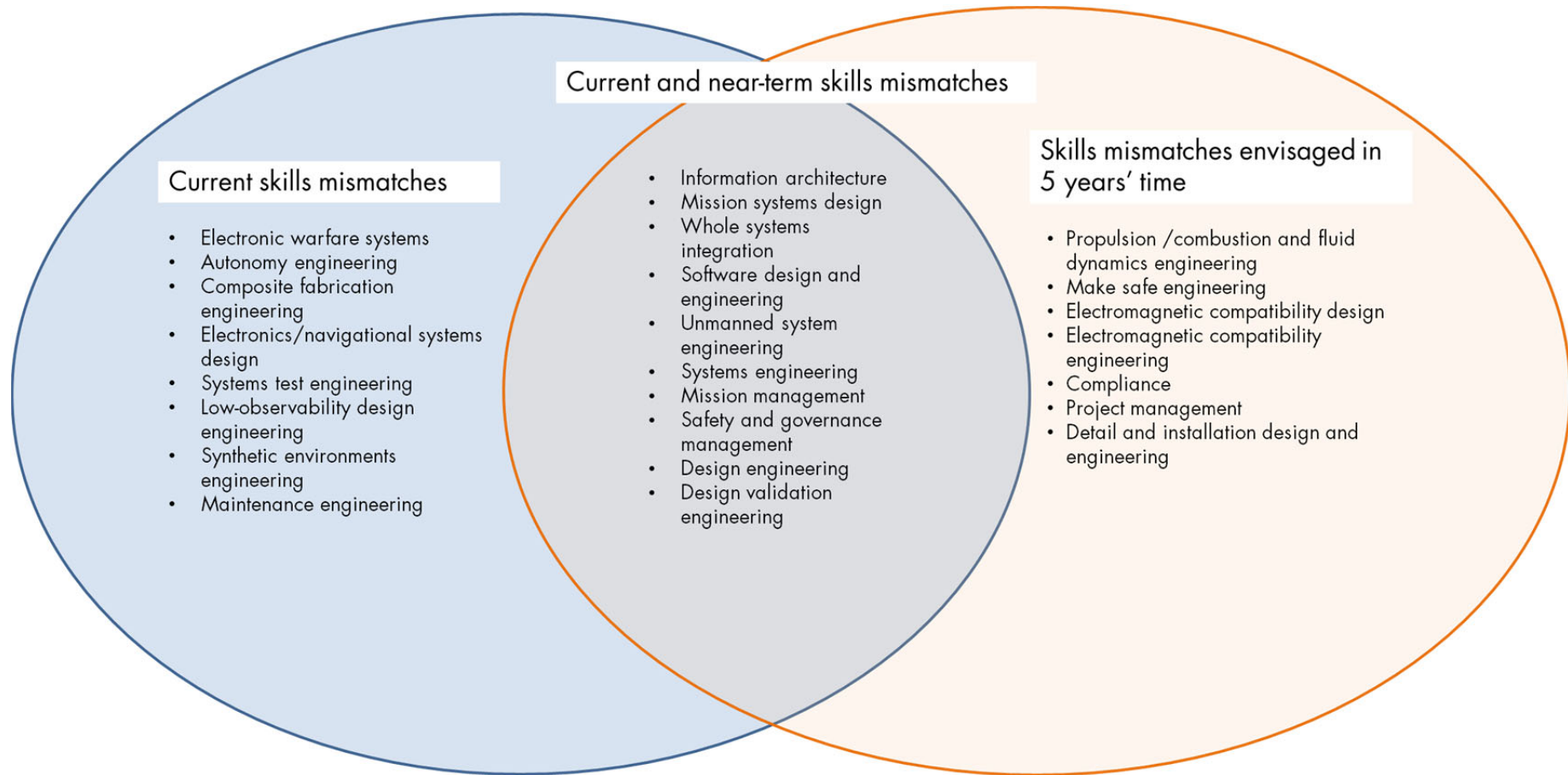
As shown in Figure A.4, there is an overlap in the skills that were prioritised by survey respondents as being those with current mismatches and those where such mismatches are foreseen for the next five years. This seems to suggest there may be a chronic difficulty to recruit and/or retain necessary skills. In other words, there may be systemic reasons for the persistent skills mismatches that defy a simple or quick fix.

While the number of reported anticipated mismatches is generally lower than for current mismatches (due to the inherent uncertainty of anticipating something in the future), the skills mismatches included in Figure A.5 nonetheless present a cause for concern. First, as most of these skills have a medium to medium-high level of specialisation to defence (see **Error! Reference source not found.**), the existence of a persisting difficulty in sourcing relevant skills may weaken European companies' ability to effectively and efficiently deliver equipment programmes. Second, it should be noted that the skills areas in the overlapping portion of the Venn diagram represent skills that are necessary to bring together different systems to deliver capability and hence have a high level of complexity and expertise requirements. As such, they require significant degree of training and cannot be transferred easily from other sectors. On a related point, these skills areas are in some way basic requirements for delivering a defence equipment programme. For most defence equipment programmes, a combination of skills from across these broad groups (i.e. information architecture, design engineering, systems integration, mission systems design, mission management and safety and governance) will be required capability in an effective and efficient manner.

Without a full dataset covering present as well as past data, it is not possible to say with full certainty whether there is a certain cyclicity of skills shortages that emerges due to the long lead times of defence equipment, i.e.: whether certain skills groups periodically atrophy during low demand in between larger equipment programmes and are then grown again once new programmes come in. This may be the case for some suppliers, particularly those with very niche system and sub-system level specialised skills, but it may be quite different for others who may face a more stable demand for their products over time

(potentially due to the dual use nature of their products, or the increased ease of offsetting periods of low domestic demand through a thriving export business). As European defence industries are assuming increasing responsibility for the whole lifecycle of the equipment as well as for providing additional support (e.g. training, simulation, logistics) it is also possible that skills gaps may become a chronic, rather than just periodic, challenge.

Figure A.5 Examples of current and near-term skills mismatches



Source: RAND Europe analysis

Another factor that may influence the persistence of skills shortages may be related to the demographic profile of the workforce, whereby retiring experts are not replaced by newly trained workforce fast enough or with sufficient opportunity to allow for knowledge transfer and mentoring to upskill this next generation of experts to the required level. Building up sufficiently qualified and experienced workforce in these specialised skills can take significant amounts of time, with some of the specialised skills requiring five or more years of training on the job to achieve full efficiency – or as many as fifteen or twenty years to become a leading expert in that field, able to lead, sign off and certify the work of others and exercise judgement on the most complex challenges (e.g. relating to safety, or deep technical complexity and uncertainty). While the prominence of these various factors will differ country by country, and company by company, some general observations on the drivers behind skills gaps and shortages can be made on the basis of our survey results as shown in the following sections.

Skills mismatches are also found in individual defence domains, which may be difficult to source given the limited pool of talent

For completeness and nuance, the survey respondents were also asked to identify any skills shortages and gaps pertaining specifically to the defence domain in which their company/organisation is active

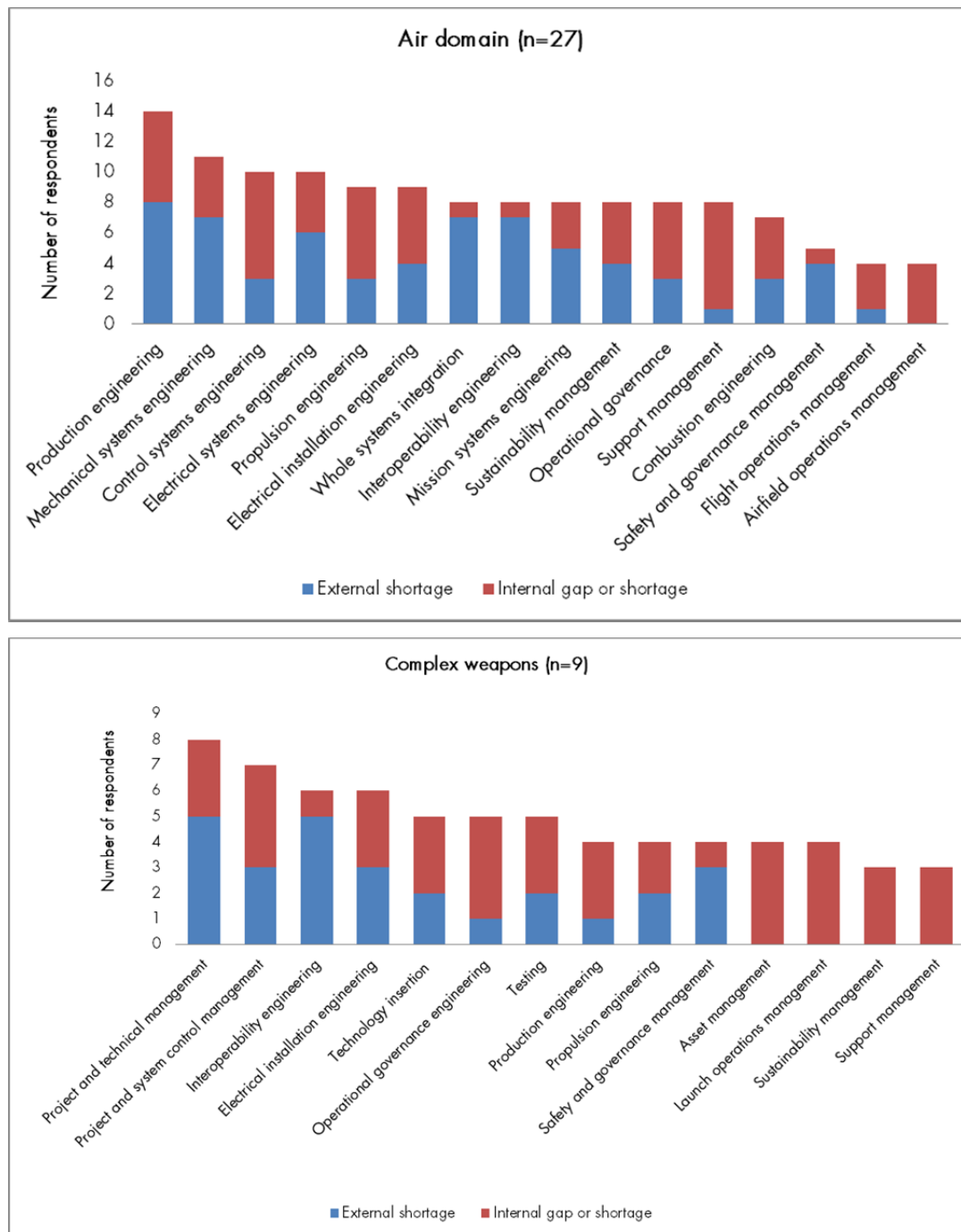
The survey provided an option to select skills from the taxonomy of domain-specific skills for six domains, including: air, complex weapons, cyber and C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance), land, naval and space. The full taxonomy is included in the *Methodologies Annex C*. While many of the gaps identified are in skills that require significant domain-specific knowledge, some commonalities emerge across the different domains, for example:

- **Interoperability design and engineering** skills are highlighted in multiple domains as a current and potential future shortage, echoing the increasingly collaborative nature of defence programmes as well as the interoperability needs between equipment and between different nations in deployed operations.
- **Safety engineering and governance** presents a skills area of concern, with challenges likely related to the increasingly complex safety and governance management and certification regimes related to the application of new technologies, as well as increasing interoperability requirements, the complexity of equipment design and the necessity to test and certify systems as they interact with each other in a system-of-systems environment. While new technologies offer new ways and means of testing and simulating the operation of new equipment designs, they also introduce new challenges in terms of the skills needed to interpret the profusion of data produced.
- **Whole system integration** is also noted as an area of skills challenge, which requires long-term expertise and understanding of the overarching architecture into which different systems fit – a combination of skills, expertise and judgement that can only be gained through delivery of complex defence programmes and awareness of a wide range of different functional areas.

Similar to the analysis of skills mismatches in general defence skills, the following charts distinguish between external skills shortages (identified through the proxy of external vacancies that were reported as difficult to fill in the last 12 months) and internal gaps that were assumed to represent the remaining portion of reported skills mismatches. Given the domain specificity of the skills included here, it is not

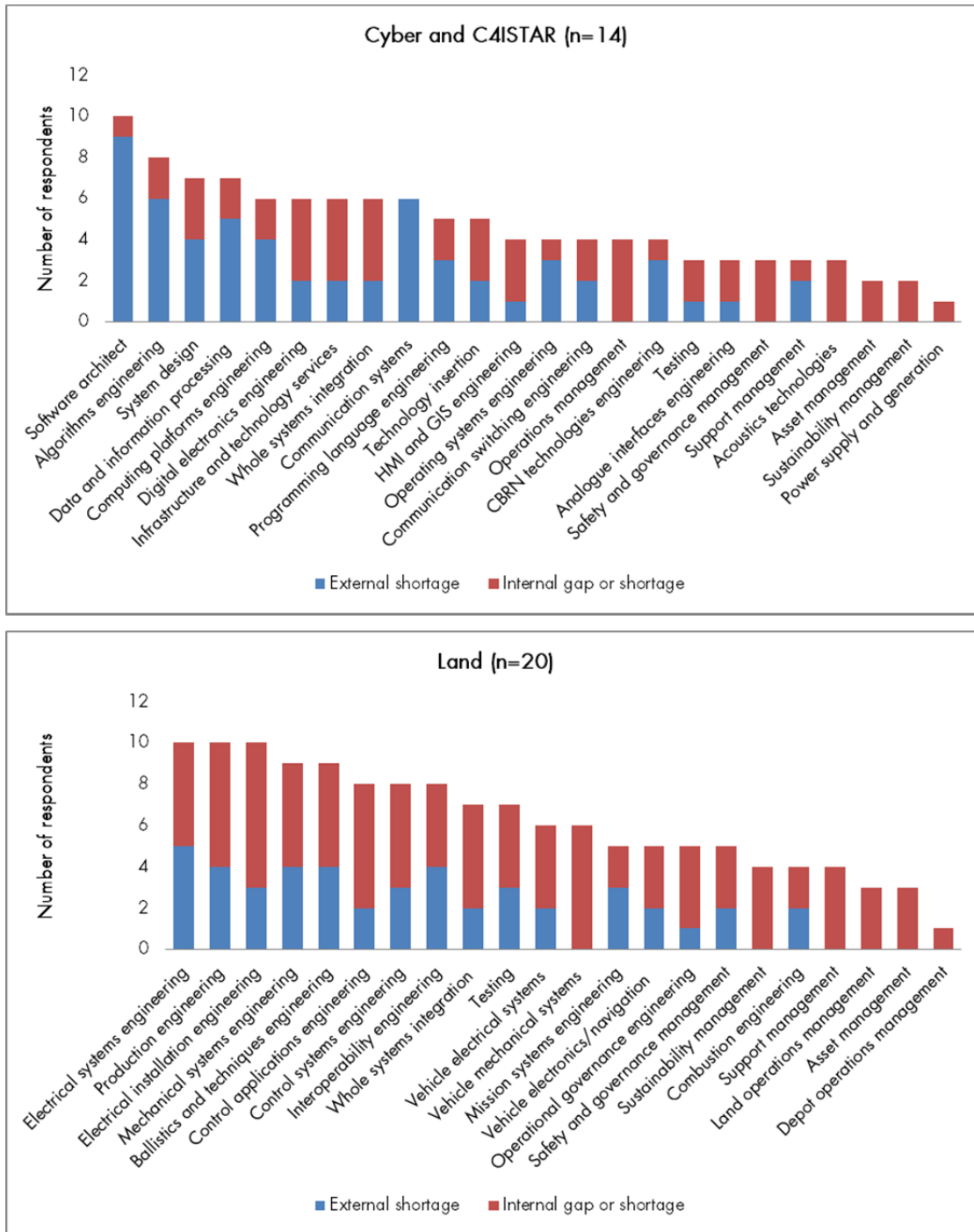
surprising that most skills mismatches can be classified as internal gaps, with only a few areas where skills can be sourced externally to the company. The most notable exception here is the cyber domain, where transferability of skills is significantly higher between the civil and defence sectors.

Figure A.6 Reported skills mis-matches in the different defence domains



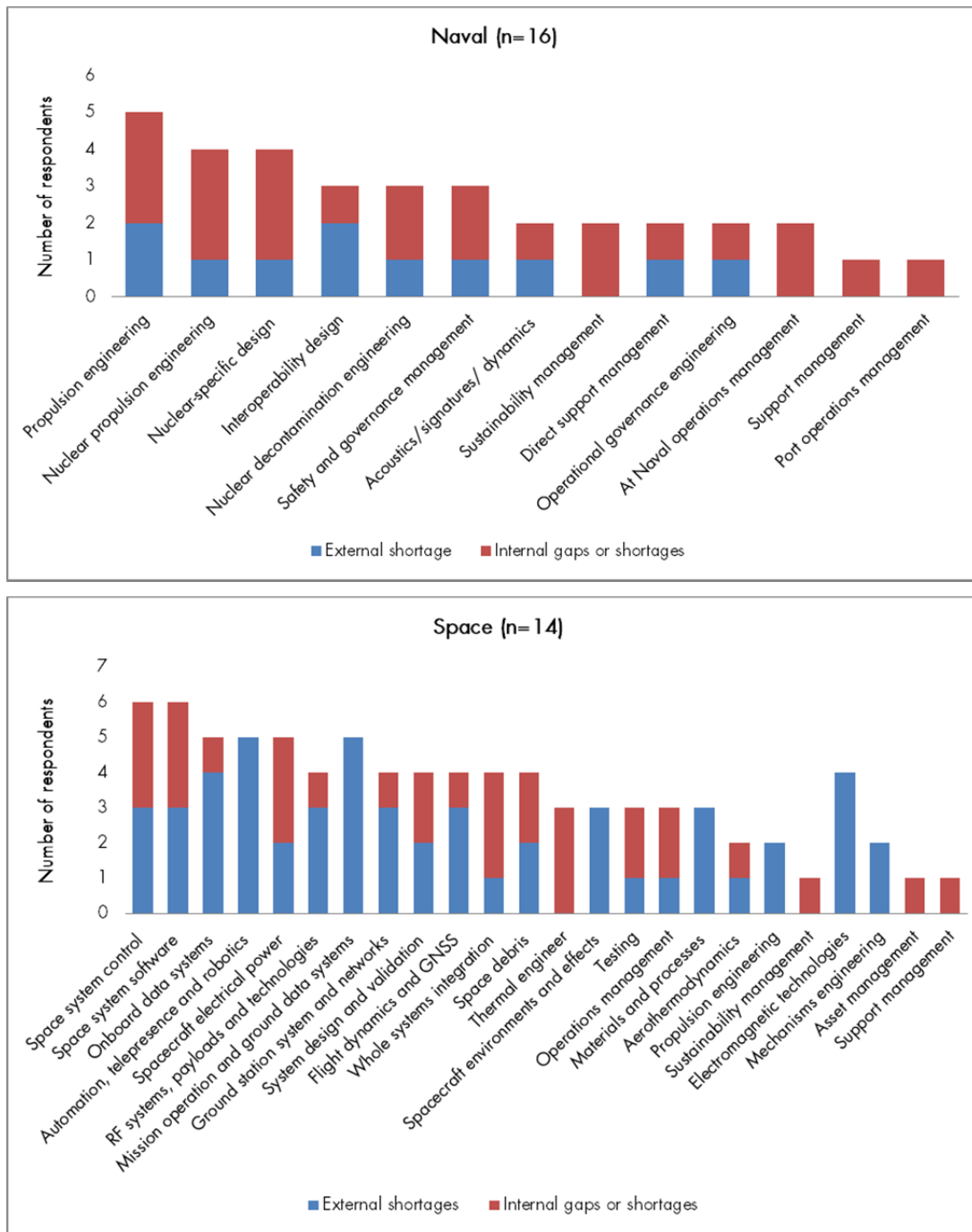
Source: RAND Europe analysis

Figure A.6 continued



Source: RAND Europe analysis

Figure A.6 continued



Source: RAND Europe analysis

For domain specific skills, low defence demand and demographic challenges are perceived to be key drivers of skills mismatches due to the high risk of skills atrophy. Similar to the technical defence skills relevant across defence domains, the perceived low attractiveness of defence is considered to play an important role in limiting the size of the early career talent pool that could enter into domain-specific jobs. This is particularly acute for cyber, where the level of transferability of skills is significantly higher between civil and defence sectors. Also similar to the broader technical skills

is the perceived lack of relevant education and training, which would enable the development of domain-specific skills.

Notwithstanding the more general reasons which are reported for all skills regardless of company type, domain or specialisation to defence, it is important to note that skills mismatches in domain-specific skills are perceived to be tightly linked to low defence demand in terms of equipment requirements (procurement and exports) and to demographics. Given the specificity of these skills to particular domains, this is not surprising. This is because the use of a specialised skills will be determined by the level of capability required, which will determine what technology should be used and how. The usage of specialised skills will, therefore, depend on the extent to which they are required at a given lifecycle stage of a given project. However, if the skill is not required, it will, naturally, atrophy. The rate of atrophy will depend on a range of factors, including: the number, age and seniority profile of individuals possessing this skill within a particular company; the length of the 'gap' between programmes that require this skill; and the ability of a company to regenerate the skill through mentoring, traineeship or another form of internal skills transfer. To identify the rate of atrophy for defence specific skills within the EDTIB would require a national-level survey of companies, taking into account the base level and profile of skills present in the company, the duration and nature of current and future programmes in which defence companies are likely to be involved, and the concrete programmes and initiatives to promote skills transfer within the company.

When considering the urgency of mismatches, SMEs face immediate challenges with project management and test engineering skills, which could hamper their ability to deliver projects effectively

When survey data is disaggregated by company size, it becomes clear that reported skills mismatches pertain primarily to SMEs (companies with less than 250 employees) and to lower tier suppliers in general (with 250-10,000 employees). In total, over 66% of SMEs responding to the survey report skills mismatches in general defence skills and over 70% of companies with more than 250 but less than 10,000 employees do so, while only about a third of companies larger than 10,000 employees have reported specific skills mismatches. When general technical skills are considered, the reported current mismatches are broadly similar between the different groups of companies and aligned with the results presented in Figure A.3.

However, when **timeframes for recruitment of skills** are considered, the immediacy of demand for programme and project management skills becomes much more apparent for smaller companies. In Figure A.7, the top skills mismatches reported by the different company sizes. The list represents skills mismatches reported by over 30% of respondents within each group.

As shown in Figure A.7, lower tier suppliers and SMEs report facing immediate challenges in recruiting and retaining sufficient skills in programme and project management, procurement and cost estimation as well as technical skills such as systems engineering and testing. In contrast, the most immediate challenges suggested by primes are within the technical fields, including:

- Software design and engineering;
- Synthetic environments engineering;

- Design validation and planning;
- Production support.

Figure A.7 Skills mismatches due to inability to source skills quickly enough - by company type

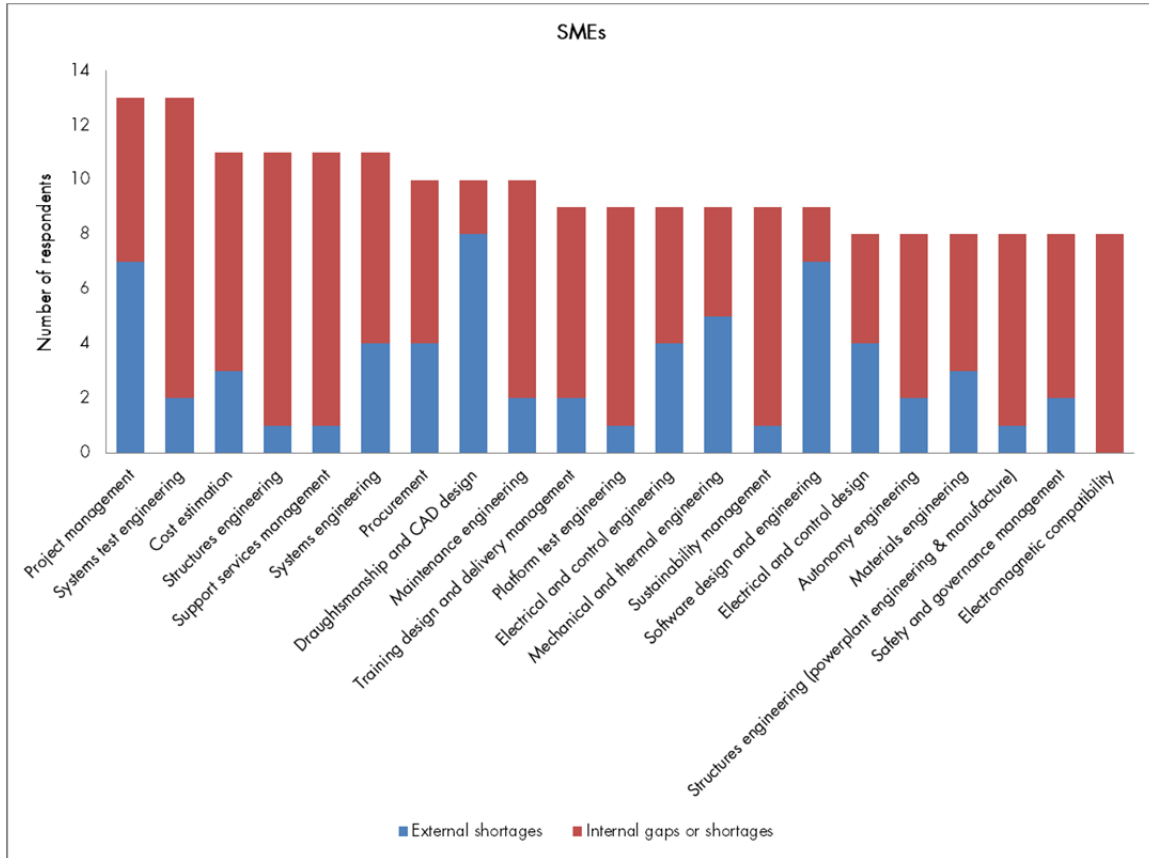
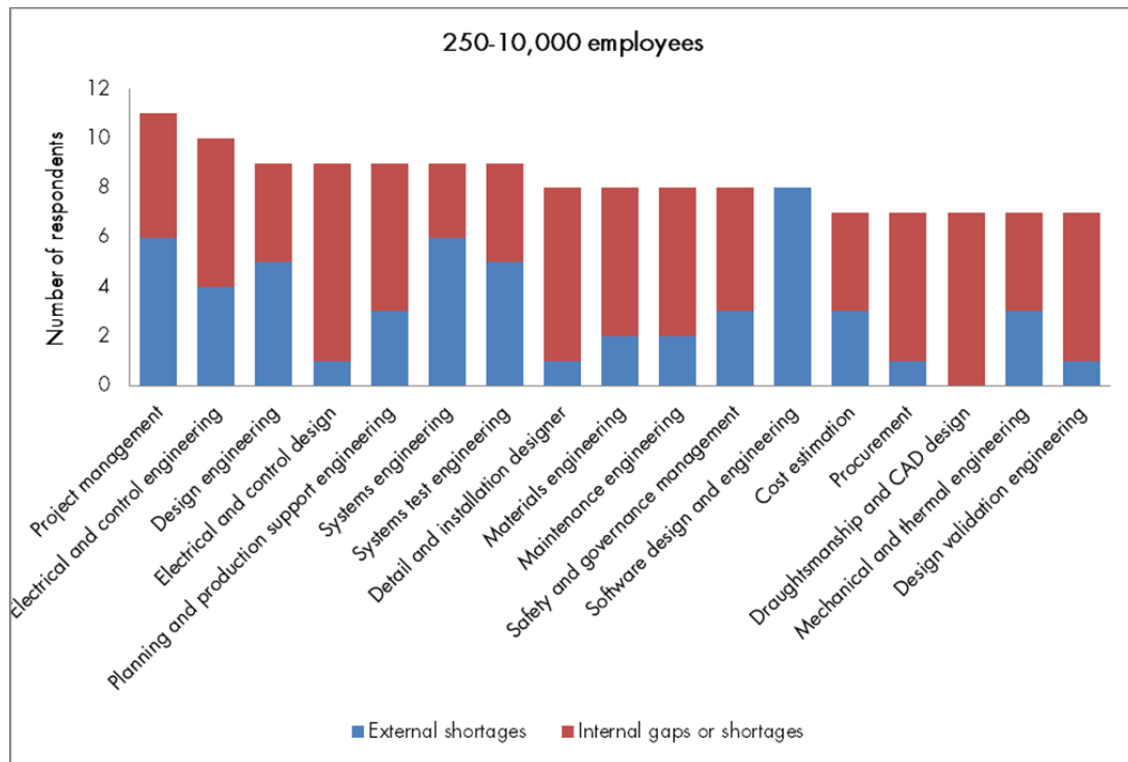


Figure A.7 continued



It is likely that programme and project management skills are well established in large companies but may be becoming an increasingly challenging recruitment field for SMEs and other lower tier suppliers with the increasing number of collaborative programmes and more complex programme requirements. The delivery of these programmes requires not only improved technical skills (particularly in relation to design of architectures, integration of systems and their testing within a system of systems environment) but also management skills (including project management, cost estimation). Without these in place, delivering complex requirements within a system of systems environment is likely to cause delays and cost growth.¹¹⁹

As explained further below, the diversity of ‘problems’ faced by different defence actors, and the range of different factors influencing the defence skills landscape require a carefully drafted approach that consciously avoids trying to implement a ‘one-size fits all’ solution to all defence skills mismatches.

While larger companies perceive insufficient defence demand to be as important as competition for talent with other sectors, for SMEs, competition for talent is one of the principal concerns

Some similarities exist between the perceived reasons behind skills mismatches across different types of companies, with inadequate education and training being reported most frequently and closely followed

¹¹⁹ On the importance of effective programme and project management, see: Birkler, J., Schank, J.F., Arena, M.V., Keating, E.G., Predd, J.B., Black, J., Danescu, I.E., Jenkins, D., Kallimani, J.G., Lee, G.T., Lough, R., Murphy, R., Nicholls, D., Persi Paoli, G., Peetz, D., Perkinson, B., Sollinger, J.M., Tierney, S. & O. Younossi. *Australia's Naval Shipbuilding Enterprise: Preparing for the 21st Century*. Prepared for the Australian Department of Defence. RAND Research Report RR-1093-AUS. Santa Monica, CA: RAND Corporation. As of 21 December 2018: https://www.rand.org/pubs/research_reports/RR1093.html

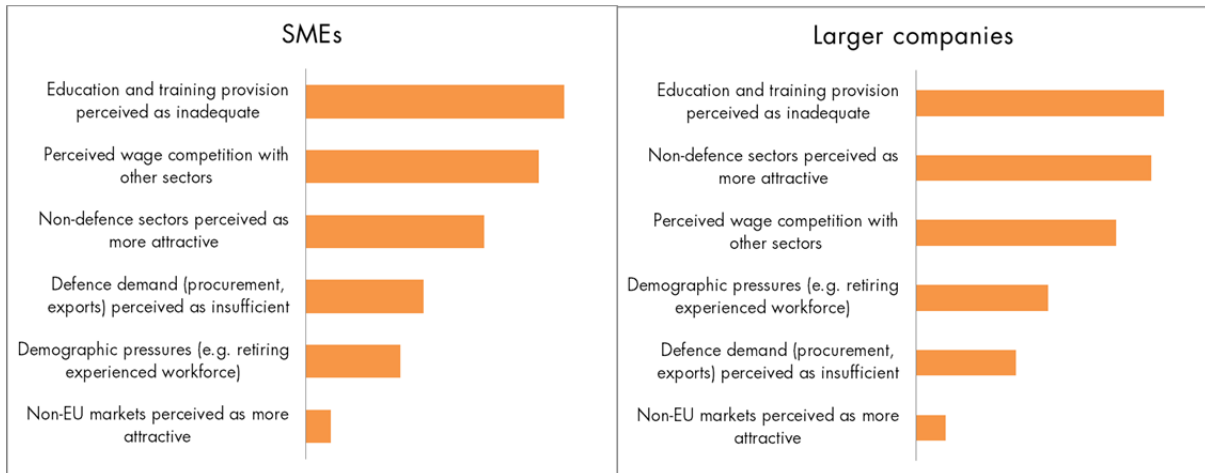
by competition for talent with other sectors (with wage competition being a specific example). As mentioned above, concerns with regard to appropriate education and training are common and expected feature of skills surveys. More interesting, however, is the relatively balanced picture of perceived reasons for skills mismatches reported by larger companies (with 250-10,000 employees). Here, it is clear that there no single reason that is perceived to drive skills mismatches but, rather, a combination of several, including:

- A mismatch between employer needs and educational/training output (in terms of both the volume and composition of the skilled workforce provided);
- Stiff competition for skilled workers from non-defence sectors – which includes perceptions of defence as unattractive, less dynamic and less well paid – suggesting an interplay between different, related drivers;
- Demographic challenges, particularly in relation to senior experienced workers who may be retiring without sufficient replacement and/or knowledge transfer;
- Insufficient demand for skills utilisation due to low defence investment nationally and/or on a European level (R&D, procurement) and/or low exports, undermining both the business case to retain these employees and the ability to test, build and develop their skills through hands-on experience on actual programmes. In order to retain currency of skills and the ability to produce competitive defence products for the domestic and global customers, defence programmes are necessary. Highly specialised defence skills, which are often ones that enable EU defence products have an operational advantage over potential adversaries, defence demand is a critical driver for skills retention and acquisition of new skills.

It is likely that defence capability development programmes will act as a stronger determinant for skills needs for companies that focus primarily on the defence market than companies with a strong dual use or civil market presence, which may be able to draw on the workforce from across the different parts of their business. For these companies, it may also be the case that the civil part of the business presents an opportunity, rather than ‘competition’ for skills. Non-defence competitors for skills will then refer to competitors external to the company (for example the finance sector, telecommunications, start-ups and others) to draw in additional talent as required. Yet, even in these cases, it is also important to bear in mind that the degree of transferability from the civil part of the business into the defence part will depend on the degree of defence specialisation required, the mobility of relevant workforce and, not least, the nationality requirements specified for the defence projects.

For SMEs, on the other hand, competition for talent, together with a perceived low attractiveness of defence work and some demographic pressures are seen to be critical factors in creating skills mismatches. With fewer resources than tier I, II and prime companies, SMEs are likely to face a fiercer challenge in both identifying and attracting talent into their defence work. Combined with perceived challenges related to the age and experience of subject matter experts, who may be too young and inexperienced or nearing retirement, SMEs may require support from primes as well as regional, national and supra-national bodies to put in place effective strategies to identify, attract and retain talent as well as to transfer existing knowledge effectively.

Figure A.8 Perceived reasons behind skills mismatches in skills by company size



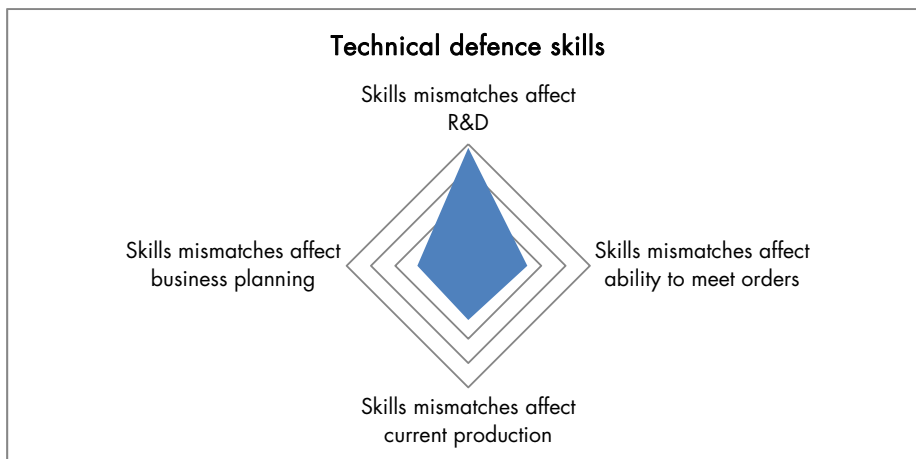
Note: The bars indicated the frequency of reported reasons for skills mismatches.

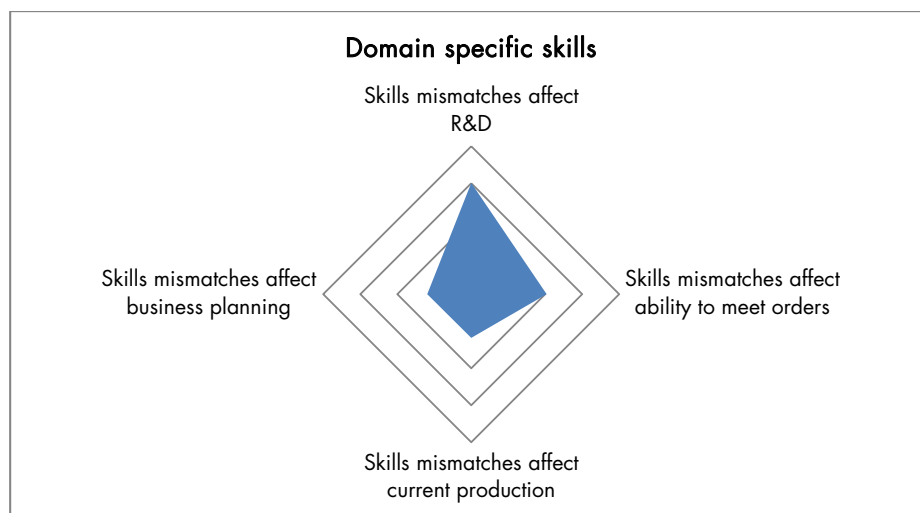
Source: RAND Europe analysis

Skills mismatches can have impact on the EDTIB, potentially undermining companies’ competitiveness and ability to innovate

As shown in previous sections, shortages and gaps in skills seem to present a persistent trend rather than a short-term, potentially cyclical phenomenon that can be resolved with targeted and temporary interventions. Responses provided by the survey participants support this hypothesis further, showing that reported skills gaps and shortages are perceived to have an impact on some of the core parts of the defence businesses, including R&D progress, delivery of orders and business planning (see Figure A.9). Without external measurement of what the impact has been it is not possible to verify the extent to which skills mismatches have affected defence companies. However, the evidence of training and education initiatives and programmes adopted by defence industry examined in Chapters 4 and 5 serves as an indication that companies face a real challenge of skills mismatches and are actively trying to address this. As such, the reported impact of skills mismatches on business processes should be considered as valuable piece of information to enhance the narrative on skills mismatches in the defence sector.

Figure A.9 Perceived impact of skills mismatches





Note: the radar plots represent the frequency of reporting impact of skills mismatches for a long list of technical skills (chart 1) and domain-specific skills. It does not represent a quantified impact in monetary or other resource terms.

The most frequently reported impact is on R&D progress, which suggests that defence industrial innovation and delivery of advanced defence capabilities could be slowed down or thwarted due to the insufficient supply of relevant skills. This correlates with the fact that most skills shortages and gaps are identified in the design and engineering. In addition to slowing innovation, skills gaps and shortages may have further effects on reducing competitiveness of the EDTIB and the quality of defence equipment. Finally, insufficient number and variety of R&D programmes as well as not enough volume to develop skills may lead to further skills shortages as fewer ‘exciting’ new programmes may mean fewer ‘exciting’ new opportunities for young STEM graduates and trainees to join defence. In this sense, there is a feedback loop between R&D programmes and skills supply in which the two reinforce each other – both in a positive and negative sense. Crucially, the reported impact (albeit not externally validated) of skills shortages and gaps on the defence industrial base validates the primary hypothesis of this report which is that there are skills gaps in the EDTIB in the first place.

Drawing on the analysis in Chapter 2, it is also important to note that the identified skills shortages and gaps introduce additional risk, cost, schedule delays and product quality issues to defence programmes. This, in turn, has an impact on European MODs and militaries in their ability to develop capabilities. The well-documented example of the Vanguard to Astute transition and gap in submarine design skills in the UK context demonstrates the impact of EDTIB skills gaps and shortages for a much wider national defence enterprise and provides a range of lessons learnt in this regard.¹²⁰

¹²⁰ See, for example: Schank, John F., Frank W. Lacroix, Robert Murphy, Cesse Cameron Ip, Mark V. Arena, and Gordon T. Lee. 2011. *Learning from Experience: Volume III: Lessons from the United Kingdom's Astute Submarine Program*. Santa Monica, Calif.: RAND Corporation. MG-1128/3-NAVY. As of September 28, 2018: <https://www.rand.org/pubs/monographs/MG1128z3.html>

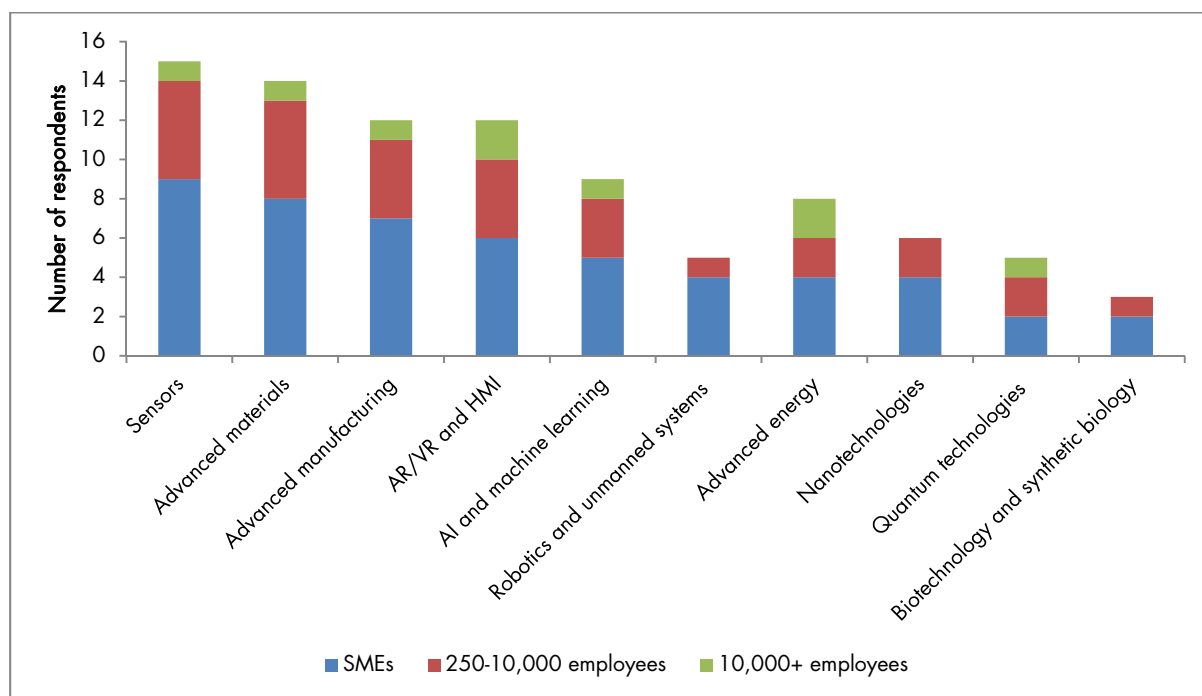
To keep pace with new technologies and to drive future innovation, the EDTIB will have to address additional skills challenges

Technology will continue to have an important impact on the need for skills in the EDTIB, both in terms of the nature of skills and their volume. Evidence from the survey responses supports this finding, showing that in the next five years, defence companies and organisations are likely to see an increased demand for skills across a range of different technology areas, including:

- Artificial intelligence (AI) and machine learning
- Embedded sensors and connectivity (e.g. wearables, Internet of Things)
- Advanced manufacturing
- Augmented/virtual reality (AR/VR) and human machine interfaces (HMI)
- Advanced / smart materials
- Robotics and unmanned systems (hardware)
- Advanced energy generation, storage and distribution (including high energy weapons, electric propulsion and energy hybridisation)
- Quantum technologies (e.g. computing, sensing) and distributed ledger technologies (e.g. blockchain)
- Nanotechnologies
- Biotechnology and synthetic biology
- New weapons technologies (e.g. smart ammunition, insensitive munitions, hydroballistics, vacuum ballistics)
- IT infrastructure (e.g. private cloud, resilient storage)

The uptake of these technologies is evident across the different types of organisations that responded to the survey. Out of the total 81 responses, 35 organisations reported they either currently work on or intend to work on at least one of the above mentioned technology areas (see Figure A.10).

Figure A.10 Survey respondents (by company size) currently working on new technologies



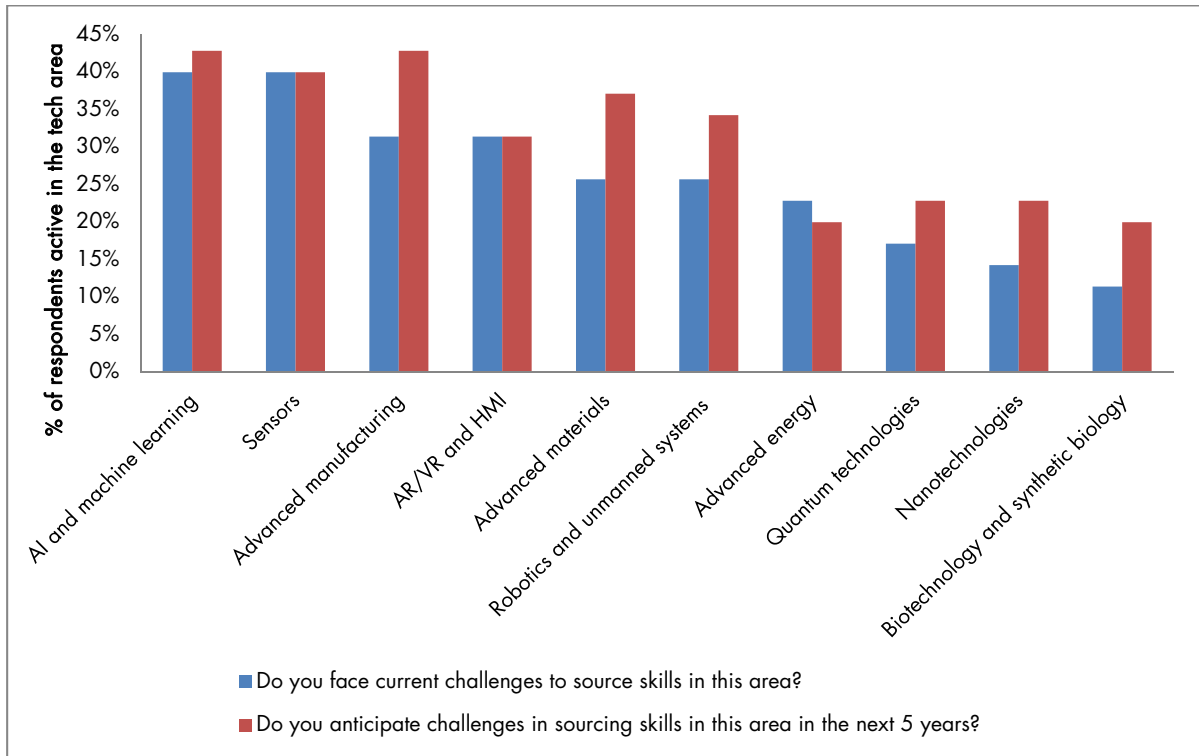
Source: RAND Europe

As shown in Figure A.10, the most frequently reported challenges in recruiting and/or retaining skills in the different technology areas are currently experienced in:

- Artificial intelligence and machine learning
- Embedded sensors and connectivity (e.g. wearables, Internet of Things)
- Advanced manufacturing
- Augmented/virtual reality and human machine interfaces

with over 30% of respondents working on these technology areas reporting a current skills gap or shortage. In the next five years, in addition to the four groups highlighted above, large gaps are also anticipated in advanced materials and robotics. Furthermore, survey respondents seem to anticipate a growth in demand for skills in quantum technologies, nanotechnologies, biotechnologies and synthetic biology and an accompanying growth in skills mismatches. These may relate to a likely increase in competition for the same skills within non-defence organisations and industries and/or to a potential lack of overall talent supply due to the sheer scale of demand if these technology areas experience a significant uptake across multiple sectors. As such, it is likely that these mismatches are a combination of external shortages and both internal and external gaps.

Figure A.11 Perceived skills mismatches now and in the future



Source: RAND Europe analysis

Annex B. Comparing European defence sector to other sectors and practices in sustaining and managing key skills

In order to complete the state of play of relevant mechanisms concerning skills supply, this chapter explores different comparators, found in other sectors, business practices and the US system. This chapter first analyses the transferability of industrial skills within defence domains and across defence and civilian sectors. It then goes on to compare existing business practises in managing and retaining talent in other sectors, namely high-tech and IT. It finally draws upon good practices of ensuring defence skills supply in the US system.

Any statements not specifically referenced in this chapter reflect the findings of RAND Europe stakeholder engagement (namely expert interviews and workshops with EDSP members). Insights obtained during the interviews are integrated throughout the report and the interview protocol can be found in Methodologies Annex.

Box B.1 Comparing European defence sector to other sectors, business practices, and the US system in terms of sustaining and managing skills – summary

- Industrial skills can be transferred within defence domains and across defence and civilian sectors
- The high-tech and IT industries experience similar retention challenges to the defence sector
- Mid-career continuous development opportunities are used across all sectors to persuade employees to remain in post while they pursue additional qualifications
- High-tech and IT industries make more use of digitally-facilitated employee engagement tools to help prevent employee attrition
- The US defence skills landscape is characterised by large-scale capability programmes and high levels of fragmentation
- Examples of good practice within the US approach to defence skills development include high levels collaboration and a focus on regional, domain and programme-specific programmes
- Similar to European national governments and the European defence industry, cyber skills are a key focus area for US Defence

Source: RAND Europe

B.1. Industrial skills can be transferred within defence domains and across defence and civilian sectors

B.1.1. Research indicates that industrial skills transferability applies to a range of defence platforms and domains

An important consideration to be made with regard to defence industrial skills pertains to the transferability that several such skills have. Research conducted on cyber, naval, and aircraft defence industry suggests that members of specialised workforce within such industries may move across different areas of a given defence domain (e.g. working on different platforms) as well as across related defence and civilian industrial sectors.¹²¹

For instance, research on defence aircraft industry conducted by RAND Europe indicates that few significant barriers exist for skilled workers to move between different aircraft domains specific to defence. More broadly, synergies and overlaps exist between the broader defence and civil aerospace sectors in terms of the competences required and technology areas employed.¹²² To be sure, some of the skills required by the defence industrial air domain are not only domain-specific, but platform-specific (e.g. low observability and combat aircraft design skills). In several instances, however, skills developed by workforce are deemed transferable. With reference to air defence industry, skills pertaining to programme management (e.g. project management; airworthiness governance; fleet management and cost estimating), systems engineering, as well as operations and logistics competences are generally applicable throughout the life cycle of all military fixed wing domains. More broadly, defence air support platforms skills are typically considered equivalent to those required for civilian commercial platforms or variants thereof, as are power plant competences required by defence and civil aerospace industries.¹²³

Equally, in the cyber domain, defence organisations are reported to engage professionals originating from outside defence when trying to meet existing demand for senior cyber professionals or for niche technical expertise. Demand for senior cyber professionals can thus lead to the hiring of self-taught professionals

¹²¹ Bassford, M., Pung, H., Edgington, N., Starkey, T., Weed, K., Arena, M.V., Kallimani, J.G., Lee, G.T. & O. Younossi. 2010. *Sustaining Key Skills in the UK Military Aircraft Industry*. Prepared for the United Kingdom Ministry of Defence. RAND Research Report MG-1023-MOD. Santa Monica, CA: RAND Corporation; Keating, Edward G., Irina Elena Danescu, Dan Jenkins, James Black, Robert Murphy, Deborah Peetz, and Sarah H. Bana. 2015. *The Economic Consequences of Investing in Shipbuilding: Case Studies in the United States and Sweden*. Santa Monica, Calif.: RAND Corporation, RR-1036-AUS. As of September 21 2018: https://www.rand.org/pubs/research_reports/RR1036.html; Silfversten, E., Flint, R., Lynch, A., Ward, A. & A. Hall. Forthcoming (2018). *Cyber Defence Specialist Models (CD SpecMods)*. Prepared for the European Defence Agency. Reference: 17.CAT.NP3.081. Not for public distribution.

¹²² Bassford, M., Pung, H., Edgington, N., Starkey, T., Weed, K., Arena, M.V., Kallimani, J.G., Lee, G.T. & O. Younossi. 2010. *Sustaining Key Skills in the UK Military Aircraft Industry*. Prepared for the United Kingdom Ministry of Defence. RAND Research Report MG-1023-MOD. Santa Monica, CA: RAND Corporation

¹²³ Ibid.

with expertise relevant to defence organisations, as well as to the transfer to defence of cyber professionals that work in civilian institutions.¹²⁴

B.1.2. Skills transferability and dual-use potential has significant implications and potential for skills supply initiatives

Although research indicates that wholesale transfer of labour across industries and domains is not possible, the implications for skills supply initiatives that stem from industrial skills transferability and from the dual-use potential of skills and competences relevant to defence industry should not be overlooked.¹²⁵ The transferability of industrial and technology skills and competences between defence and civilian sectors and the positive impact that defence industrial developments can attain has already been observed at a European level. For instance, Sweden's Gripen Programme has been lauded for successfully delivering an advanced fighter aircraft, while also producing a significant economic multiplier within the local and national economies.¹²⁶

Bearing this in mind, although industry-led skills supply programmes are primarily meant to enable their beneficiaries to develop a career in a specific industry, **the majority of initiatives in place foster skills that are often dual-use in nature and that can benefit European industry beyond an individual sector (e.g. defence)**. This is particularly relevant to consider and of potential added value for companies whose business portfolio spans beyond the defence sector and who could thus be able to train and subsequently shift skilled personnel across different business areas, according to market demand and business needs. Furthermore, this may contribute to increasing the overall attractiveness of defence industry-led programmes for potential beneficiaries who would receive training enabling them to pursue an array of different career pathways without committing upfront to a career in defence. This may help attract participants, especially in countries where industry laments difficulties encountered in attracting talent to the defence sector due to the overall negative perception of the field. Box B.2 presents an example of a skills supply initiative whose scope and approach has the potential for benefitting both defence and civilian industries.

¹²⁴ Silfversten, E., Flint, R., Lynch, A., Ward, A. & A. Hall. Forthcoming (2018). *Cyber Defence Specialist Models (CD SpecMods)*. Prepared for the European Defence Agency. Reference: 17.CAT.NP3.081. Not for public distribution.

¹²⁵ Bassford, M., Pung, H., Edgington, N., Starkey, T., Weed, K., Arena, M.V., Kallimani, J.G., Lee, G.T. & O. Younossi. 2010. *Sustaining Key Skills in the UK Military Aircraft Industry*. Prepared for the United Kingdom Ministry of Defence. RAND Research Report MG-1023-MOD. Santa Monica, CA: RAND Corporation

¹²⁶ Keating, Edward G., Irina Elena Danescu, Dan Jenkins, James Black, Robert Murphy, Deborah Peetz, and Sarah H. Bana. 2015. *The Economic Consequences of Investing in Shipbuilding: Case Studies in the United States and Sweden*. Santa Monica, Calif.: RAND Corporation, RR-1036-AUS. As of September 21 2018: https://www.rand.org/pubs/research_reports/RR1036.html; Birkler, J., Schank, J.F., Arena, M.V., Keating, E.G., Predd, J.B., Black, J., Danescu, I.E., Jenkins, D., Kallimani, J.G., Lee, G.T., Lough, R., Murphy, R., Nicholls, D., Persi Paoli, G., Peetz, D., Perkinson, B., Sollinger, J.M., Tierney, S. & O. Younossi. *Australia's Naval Shipbuilding Enterprise: Preparing for the 21st Century*. Prepared for the Australian Department of Defence. RAND Research Report RR-1093-AUS. Santa Monica, CA: RAND Corporation.

Box B.2 The UK Bombardier Aerospace Apprenticeship and Graduate programmes

The UK Bombardier's Aerospace Apprenticeship and Graduate programmes are examples of skills supply initiatives fostering dual-use skills that could benefit both civilian and defence industry. These programmes are designed to lead their beneficiaries to obtain formal certifications in Aeronautical Engineering by taking part in a multi-year programme combining study with on-the-job training and learning. In particular, after a first introductory year of off-the-job training, beneficiaries are rotated across various operational areas of UK Bombardier with a view to developing skills and knowledge required to successfully integrate into work on completion of their apprenticeship. The certifications achieved through the UK Bombardier programmes can facilitate access into a defence aerospace career without restricting an individual's career pathway to it or to a single company.¹²⁷

More broadly, resource sharing (involving more than just joint funding), can also include **exchanges in personnel to cross-pollinate knowledge and provide guidance for industry-relevant curricula**. For example, in France's École Nationale Supérieure de Techniques Avancées Bretagne, industry personnel serve as teaching staff to ensure that students are equipped with industry-relevant skills and are encouraged to join the industry. Similarly, compatibly with constraints and requirements of a competitive market economy, there appears to be margin for **improving cross-industry coordination to minimise duplication of efforts in the design and running of supply programmes and to achieve economies of scale and results otherwise untenable through stove-piping**. Furthermore, for initiatives fostering dual-use skills and competences, greater coordination should be sought also with companies outside of the defence world. Where cross-industry coordination has occurred, positive results have been achieved. For instance, in France a wide array of defence companies have established partnerships designed to improve recruitment and retention. An example of this comes from the consortium of companies, industry associations and clusters collaborating with the Adecco Group, ASTech, and the Aerospace Competitiveness Cluster of the Greater Paris Region. These partners will help defence companies with issues of industrial innovation, skills training, and recruitment.

B.2. Comparison of existing business practises in managing and retaining talent in other sectors to defence

Skills retention is a key priority for the defence industry, particularly given the existing skills shortages and gaps in key competences for defence. Good practice from the retention strategies of non-defence industries can be identified. Other industries requiring high-grade engineering and technology talent, but experiencing high turnover-- such as the civil high-tech and IT industries--are able to offer relevant insights into business practices and strategies for skills retention. At the same time, one unique feature to the defence sector is the defence industry's ability to offer employees the opportunity to contribute to historic and technologically highly advanced defence programmes. Particularly in the aerospace sector, military fighter aircraft continues to be one of the most technologically advanced products available to challenge high-performing talent. Talented individuals drawn to this opportunity are also likely to remain in this industry.

¹²⁷ (Industry webpage) Bombardier. 2018. 'Apprenticeship programme.' As of 27 September 2018: <https://uk.bombardier.com/en/careers/students-graduates/apprenticeship-program.html>

B.2.1. The high-tech and IT industries experience similar retention challenges and have some broadly comparable approaches to addressing them as the defence sector

The high-tech and IT industries are useful comparators for the defence industry as they rely on innovation, have overlapping areas of activity with the defence industry and each other, and exhibit similar skills requirements to the defence sector. The similarly high demand for engineering, software development, software engineering and cyber skills in the high-tech and IT industries means that these industries also compete with the defence sector to recruit high-grade talent. An all-encompassing and widely acknowledged definition for ‘high-tech industries’ is difficult to establish, but a few examples of high-tech industries include design and manufacturing in advanced robotics and artificial intelligence; autonomous vehicles; virtual reality and renewable energy.

Mid-career continuous development opportunities are used across all sectors to persuade employees to remain in post while they pursue additional qualifications. The IT industries can include software development; online retail and services; and cyber. One of the most common retention strategies across all sectors is to offer mid-career educational and progression programmes. In-house mid-career development programmes that equip employees with additional certifications and degrees could be a **strong incentive for employees seeking development opportunities to pursue additional qualifications within the organisation, while generating income.**

B.2.2. High-tech, IT and defence companies similarly seek to project an innovative reputation

In order to maintain defence companies’ existing pool of talent, high-tech, IT and defence companies seek to **cultivate and maintain an innovative image that offers a stimulating working environment for high-grade talent.** This involves not only companies’ association with innovative products and services, but also with an innovative internal corporate culture, ability to integrate innovations and novel technologies in their work processes, high-tech facilities (Box B.3) and a future-oriented working environment that is open to change and risk-taking.

Several high-tech, IT and defence companies publicise their activities in experimental innovation and initiatives that show leadership in technology advancements. Amazon Robotics markets itself as “the epicentre of robotic innovation.”¹²⁸ DeepMind pursues artificial intelligence research and development leveraging the market knowledge and talent of Google - its parent company.¹²⁹ Similarly, defence companies seek to project an innovative image. Saab highlights its R&D activities in graphene – as the

¹²⁸ (Industry webpage) Amazon Robotics. 2018. ‘Our Vision.’ As of 22 October 2018: <https://www.amazonrobotics.com/#/vision>

¹²⁹ (Industry webpage) DeepMind. 2018. ‘About DeepMind for Google.’ As of 22 October 2018: <https://deepmind.com/applied/deepmind-google/>

relatively recently discovered advanced material continues to draw widespread attention,¹³⁰ while Rolls-Royce highlights its pioneering role in 3-D printing.¹³¹

Box B.3 Lockheed Martin's strategic use of high tech facilities and equipment for retention

In the U.S., defence companies such as Lockheed Martin leverage their manufacturing ability and access to high tech facilities and equipment to increase morale and strengthen retention. Lockheed Martin's innovation lab is equipped with laser jet prototypes, 3-D printers, virtual and augmented reality headsets, an animation lab for quick visualisations of concepts, advanced robotics and a sensor, optics and laser testing site. The innovation lab is designed to be a space for playful, experimental innovation that allows employees to develop ideas into prototypes. The company also seeks to ensure that new hires are able to access technology and facilities as soon as they enter the company and no longer expect workers to work in mundane, behind-the-scenes roles before they become more seasoned enough to access advanced technology.

Source: Santana (2018); Putre (2016)¹³²

High-tech, IT and defence industries also conduct **activities to nurture start-ups, which bolster the company's credibility as a source of high value expertise**. Samsung collaborates with start-ups to provide mentoring support to develop and commercialise start-ups' innovations.¹³³ There is evidence of similar activities in the defence industry. BAE Systems has played an advisory role in skills development programmes for adjacent technology industries – for example by contributing BAE Systems personnel to mentor start-up employees for the Cyber London cyber security incubator.¹³⁴

In defence, business practices around retention **underscore the opportunity for talent to contribute lasting influence to historic defence engineering milestones**. Saab emphasises its 'history of high technology' in fighter aircraft¹³⁵ and Damen capitalises on its pioneering role in the concept of modular construction in the maritime domain.¹³⁶ This could be a powerful incentive for engineers attracted to the opportunity to work on high-profile and stimulating challenges. A limited number of defence companies are able to offer these opportunities, which could contribute to skills retention.

¹³⁰ (Industry webpage) Saab. 2015. 'Innovation in every fibre.' As of 22 October 2018: <https://saabgroup.com/media/stories/stories-listing/stories-of-innovation/innovation-in-every-fibre/>

¹³¹ (Industry webpage) Rolls-Royce. 2018. 'Taking 3-D printing to new heights.' As of 22 October 2018: <https://www.rolls-royce.com/media/our-stories/innovation/2017/alm.aspx#overview>

¹³² (Blog post) Santana, Marco. 2018. 'Lockheed Martin hopes new lab inspires workforce, attracts future employees.' As of 22 October 2018: <https://phys.org/news/2018-09-lockheed-martin-lab-workforce-future.html>; (Blog post) Putre, Laura. 2016. 'Millennial retention needs more attention.' As of 22 October 2018: <https://www.industryweek.com/recruiting-retention/millennial-retention-needs-more-attention>

¹³³ (Industry webpage) Samsung. 2017b. 'Samsung opening up to startups and partners.' As of 22 October 2018: <https://news.samsung.com/global/samsung-opening-up-to-startups-and-partners>

¹³⁴ (Blog post) Wright, Andy. 2017. 'BAE Systems' approach to innovation in a changing world.' As of 22 October 2018: <https://www.baesystems.com/en/blog/bae-systems-approach-to-innovation-in-a-changing-world>

¹³⁵ (Industry webpage) Saab Group 2018c.. 'A history of high technology.' As of 22 October 2018: <https://saabgroup.com/about-company/history/>

¹³⁶ (Industry webpage) Damen. n.d. 'Students & Starters.' As of 25 September 2018: <https://career.damen.com/en/students>

B.2.3. Commercial industries use specialised retention strategies tailored for business critical talent

One business practice that features more prominently in the high-tech and IT industries as opposed to the defence sector is the specialisation of retention strategies for high-performing talent. High-performing talent is crucial to the innovation potential of any industry, but is also a group that is most likely to change employers relatively early due to the high demand for their skills.¹³⁷ In addition to high-performing talent, ‘hidden gems’ can be equally important to sustain the capabilities of an organisation. Examples of ‘hidden gems’ could be a product development manager in an acquired company that may no longer be on the organisation’s list of ‘high-potential talent,’ but may nevertheless be instrumental in upholding quality standards in a healthy product pipeline.¹³⁸ **The identification of these individuals and the enforcement of targeted retention interventions for these groups could be conducive to higher retention rates.**¹³⁹

Another incentive that could contribute to retention is providing **flexible work structures for critical talent, by giving them time to pursue personal projects and adaptability to family-oriented concerns.** In the high tech industry, time sovereignty to support high performing talent’s individual innovation and experimentation can be an attractive prospect for retention of individuals who are motivated by their passion for technology. Although top-down management of project portfolios may be necessary, providing flexibility to give time and space for innovation could help engineers recharge after strenuous projects,¹⁴⁰ and prevent employee attrition that could lead to turnover. Based on this research, few defence companies offer flexible work structures, with one exception being MTU Aero Engines, which promotes a view of time sovereignty as a condition for productivity.¹⁴¹ Employees are offered a sabbatical period of around two to six months that can be spent on personal projects and the company is open to flexible structures such as telecommuting.¹⁴²

In the high tech industry, some companies are experimenting with a policy of **rotating high performers.**¹⁴³ Rather than a linear development path where a new hire starts in a particular domain and advances vertically to assume greater responsibility, some technology companies are rotating talent across business segments and operational functions.¹⁴⁴ This could help spread high performers’ contribution across

¹³⁷ (Blog post) Cosack, Sabine, Guthridge, Matthew, and Lawson, Emily. 2010. ‘Retaining key employees in times of change.’ As of 22 October 2018: <https://www.mckinsey.com/business-functions/organization/our-insights/retaining-key-employees-in-times-of-change>

¹³⁸ Ibid.

¹³⁹ Ibid.

¹⁴⁰ (Blog post) Kaplan, James, Khan, Naufal and Roberts, Roger. 2012. ‘Winning the battle for technology talent.’ As of 22 October 2018: <https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/winning-the-battle-for-technology-talent>

¹⁴¹ MTU Aero Engines. 2016. ‘Human Resources Report 2015/2016.’ As of 18 September 2018: http://www.mtu.de/fileadmin/EN/7_News_Media/2_Media/Brochures/Staff/Personalbericht_2016_Englisch.pdf

¹⁴² Ibid.

¹⁴³ (Blog post) Kaplan, James, Khan, Naufal and Roberts, Roger. 2012. ‘Winning the battle for technology talent.’ As of 22 October 2018: <https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/winning-the-battle-for-technology-talent>

¹⁴⁴ Ibid.

technology domain areas and business segments, as well as equip high performers with multi-faceted experience that helps prevent feelings of career ‘staleness.’¹⁴⁵

The defence industry is less active than other sectors in tackling issues such as fairness and inclusivity to increase retention rates

Issues regarding fairness, diversity and inclusivity appear to be tackled more actively and systematically in the high-tech and IT industries, as opposed to the defence sector – although defence industries are acknowledge these issues.

Box B.4 The criticality of fairness and inclusivity according to a ‘Tech Leavers Study’

A 2017 U.S.-wide study examined the reasons for high turn-over in the tech industry and found that unfair treatment was the most frequently cited reason for turnover, particularly for professionals from underrepresented socio-cultural backgrounds. Over 37% of the study sample reported that unfair treatment was a major factor in the decision to leave the company - more than being recruited by another company offering a better opportunity (22%). The proposed recommendations of the study include the development and implementation of a diversity and inclusion strategy, and the establishment of inclusive and fair management cultures and processes. This could involve implementing codes of conduct that reinforce values, continuously evaluating and improving corporate culture, examining data by each demographic group, providing transparency regarding corporate culture issues and actively tackling areas of concern. Audit performance management, implementing management training and strategies that mitigate bias could also be effective policy levers.

Source: Scott et al. (2017)

B.2.4. High-tech and IT industries make more use of digitally-facilitated employee engagement tools to help prevent employee attrition

Some companies in high-tech and IT industries are experimenting with digitally-facilitated data gathering methods to support retention-relevant information gathering efforts (See Box B.5 and Box B.6). There is less publically available evidence of these practices in the defence industry, but similar evidence-based approaches could be useful for companies in the defence sector to consider.

Box B.5 Google’s employee analytics system

The tech industry has some of the highest turnover rates compared to other sectors, and companies like Google only have an average retention rate of 1.9 years.¹⁴⁶ As a result, Google has actively pursued data gathering initiatives for higher retention. Google’s ‘people operations’ department uses a combination of data analytics and external social science consultants to understand the effectiveness of corporate strategies. Google’s People & Innovation Lab (PiLab), which is comprised of social scientists with backgrounds in psychology, behaviour economics, organisational behaviour and sociology. PiLab scientists

¹⁴⁵ Ibid.

¹⁴⁶ (Blog post) Paysa. 2017. ‘Tech Tenure: the average number of years at tech disruptors and titans.’ As of 22 October 2018: <https://www.paysa.com/blog/wp-content/uploads/2017/07/DisruptorsA8.png>

observe the impacts of corporate strategies – including those that relate to retention policies. The scientists identify relationships, trends or special populations based on the large volumes of data collected. The PiLab seeks to understand questions such as: how many reminders are optimal to support processes, whether managers are necessary and if companies can be implemented without them, and what common skills are required of managers. The aim is to ensure that all corporate strategies such as those that seek to increase retention are evidence-based.

Source: Manjoo (2013)

Box B.6 IBM's 'Proactive Retention' HR data analytics and 'Blue Matching' career mobility tools

IBM has initiated a software tool called 'Proactive Retention' that employs data analytics and machine learning to calculate the relative importance of retention risk factors, without compromising employee privacy. The tool is envisaged to support decision-making for managers by equipping them with information on employee location, pay, skills and job types. IBM reports that the tool has saved the company €261.5 million based on the cost to the organisation of hiring and up-skilling replacements.

IBM has also developed a tool called 'Blue Matching', which delivers tailored internal job alerts to employees to match them with internal vacancies. The tool is aimed at supporting employees' awareness of internal positions that they may not have considered could fit their skills profile. Crucially, the tool seeks to facilitate internal career growth, which is the leading reason that causes employees to leave their employer. The opportunity to pursue career progression internally could increase employee retention.

Source: Meister (2018)

As consistently high-profit companies, some of Google and IBM's talent acquisition and retention challenges are atypical, but some lessons may be applicable to other industries such as the defence sector.

Some defence companies **monitor and evaluate internal processes and structures to track and reinforce progress that could help pre-empt employee attrition**. For example, BAE Systems uses a number of internal communications methods such as digital communication channels, leadership blogs, newsletters, management and team meetings and team briefs on a monthly basis.¹⁴⁷ ThyssenKrupp carries out a group-wide employee survey to ask for feedback on management, cooperation and wellbeing.¹⁴⁸ However, even large defence companies typically do not have designated departments to track progress on retention and rely less on digital technologies that utilise machine learning to track relevant employee data.

To sum up, retention strategies across the high-tech, IT and defence sectors are largely similar. One common strategy across these sectors is to leverage the stimulating and high-tech working environment their workplaces can offer to retain talent, although the opportunity to partake in high-profile defence programmes is unique to the defence sector. Mid-career development opportunities that shape employee skillsets and offer potential leavers with the opportunity to pursue qualifications in-house also feature widely across these sectors. Flexible and tailored work structures for the high-performing, high potential and other critical individuals in the workforce appear to be less widely utilised in the defence industry.

¹⁴⁷ (Industry webpage) BAE Systems. 2014. 'Corporate Responsibility Summary.' As of 22 October 2018: <https://www.baesystems.com/en/download-en/20151109145637/1434555667591.pdf>

¹⁴⁸ (Industry webpage) ThyssenKrupp. 2016. 'Annual report 2015/2016.' As of 22 October 2018: https://www.thyssenkrupp.com/media/investoren/berichterstattung_publicationen/update_24_11_2016/en_4/archiv_3/thyssenkrupp_gb_en_2015_2016.pdf

Finally, employee engagement is prioritised across all sectors, but there are examples of cases in the high-tech and IT industries that demonstrate more use of digital tools and artificial intelligence to support employee engagement initiatives.

B.3. Comparison with the US system of ensuring defence skills supply

US defence skills programmes differ from those of EU countries in terms of their size, scope, and level of fragmentation. Skills requirements in the US are driven by capability programmes that are significantly supported by a much larger budget than their European counterparts, while sustaining the industrial skills base remains high on the policy agenda within the Department of Defence (DoD).¹⁴⁹ The size of the US defence budget also allows for larger, more sustained investment in defence skills development.¹⁵⁰ Defence skills programmes in the US are characterised by:

- Collaboration between government, industry and academia at the national and state levels;
- Large number of defence education institutions specialising in specific domains or skills areas;
- Prevalence of regional programmes.

Most notably, skills programmes in the US are largely decentralised and clustered in regions with ongoing defence capability programmes. Industry often plays a significant role in workforce development in these regions, supporting and shaping the content of education programmes to ensure access to a local workforce equipped with skills tailored to industry requirements.

B.3.1. The US defence skills landscape is characterised by large-scale capability programmes and high levels of decentralisation

The US defence skills landscape is distinct from Europe's in a several key aspects – most notably in terms of the nature of the capability programmes that generate skills requirements. The US has the world's largest defence budget¹⁵¹ which is reflected in the size of its capability programmes. As a result of these factors, US capability programmes are much larger than those of European Member States in terms of both equipment volume and budget.¹⁵² The US is also the largest global exporter of defence equipment¹⁵³

¹⁴⁹ Department of Defense (DoD). 2016. 'Department of Defense STEM Strategic Plan FY2016 – FY2020'. As of 23rd October 2018:

https://www.acq.osd.mil/rd/publications/docs/DoD_STEM_Strategic_Plan_2015_1022_final.pdf

¹⁵⁰ Business Wire. 2018. 'Future of the US Defense Industry 2017-2022: Market Attractiveness, Competitive Landscape and Forecasts'. As of 23rd October 2018: <https://www.businesswire.com/news/home/20180117005809/en/Future-Defense-Industry-2017-2022---Market-Attractiveness>

¹⁵¹ Business Wire. 2018. 'Future of the US Defense Industry 2017-2022: Market Attractiveness, Competitive Landscape and Forecasts'. As of 23rd October 2018: <https://www.businesswire.com/news/home/20180117005809/en/Future-Defense-Industry-2017-2022---Market-Attractiveness>

¹⁵² (Blog) PR Newswire. 2018. 'United States Defence Industry Report 2017-2022'. As of 23rd October 2018: <https://www.prnewswire.com/news-releases/united-states-defense-industry-report-2017-2022-300583939.html>

¹⁵³ Business Wire. 2018. 'Future of the US Defense Industry 2017-2022: Market Attractiveness, Competitive Landscape and Forecasts'. As of 23rd October 2018:

and requires a large and highly capable defence industrial base (DIB) in order to sustain this. As these capability programmes drive skills demand, there is a correspondingly prominent need to develop and sustain the industrial skills base in the US and this is apparent in both the number of, and scale of investment in, skills development programmes throughout the country.

The US approach to defence education and training is largely decentralised. Colleges and other training providers usually design their own curricula, often in collaboration with local employers.¹⁵⁴ As a result, learning outcomes are less clearly defined and there are a limited number of common qualification frameworks at the national level. This can create challenges when it comes to transferring workers between companies or across state boundaries – a lack of nationally recognised standards or certification can create issues with skills transfer and employability, and lead to duplication of training time and costs for companies.¹⁵⁵ On the other hand, this decentralised system can be beneficial in that the skills developed at the local level are tailored to the requirements of local employers. For further detail and examples of regional and local skills programmes, see section B.3.2.

Finally, the US has a number of academic institutions specialising in particular domains or areas relevant to defence. Programmes at these institutions often target more strategic, less technical skillsets in areas such as acquisition, exports, military strategy, leadership and programme management. The Defense Acquisition University (DAU), for example, offers training in acquisition, technology and logistics to military and civilian DoD staff and defence contractors.¹⁵⁶ The Defense Institute of Security Cooperation Studies (DISCS) offers a range of short residential or online courses for existing military and defence personnel which aim to develop skills in areas such as: defence exports; technology transfer; international programmes and security requirements; programme management; policy development; and Foreign Military Sales (FMS).¹⁵⁷ Domain-specific programmes, meanwhile, include the Military Education Level 1 qualification provided by the United States Army War College; this qualification provides military personnel with skills in areas such as strategic leadership, defence management and strategic research.¹⁵⁸ The Naval Postgraduate School, meanwhile, provides not only postgraduate qualifications to military and civilian DoD personnel, but also offers STEM research internships to high school, community college and graduate students in partnership with local education providers.¹⁵⁹

<https://www.businesswire.com/news/home/20180117005809/en/Future-Defense-Industry-2017-2022---Market-Attractiveness>

¹⁵⁴ Aerospace Industries Association (AIA). 2016. 'State of the Industry Report'. As of 23rd October 2018: http://www.aia-aerospace.org/wp-content/uploads/2016/12/AIA_StateOfIndustryReport_2016_V8.pdf

¹⁵⁵ National Association of Manufacturers (NAM). 2014. 'Overcoming the manufacturing skills gap'. As of 23rd October 2018:

<http://www.nam.org/Issues/Workforce-and-Immigration/Workforce-Task-Force-Toolkit/Overcoming-the-Manufacturing-Skills-Gap-2147476066/>

¹⁵⁶ Defense Acquisition University (DAU). Homepage. As of 23rd October 2018: <https://www.dau.mil/>

¹⁵⁷ Defense Institute of Security Cooperation Studies (DISCS). Homepage. As of 23rd October 2018: <http://www.discs.dsca.mil/>

¹⁵⁸ Army War College. 2018. 'Military Education Level 1 Programs'. US Army. As of 23rd October 2018: https://www.armywarcollege.edu/programs/mel_1.cfm

¹⁵⁹ Naval Postgraduate School (NPS). 2018. 'STEM'. As of 23rd October 2018: https://www.armywarcollege.edu/programs/mel_1.cfm

B.3.2. Examples of good practice within the US approach to defence skills development include high levels collaboration and a focus on regional, domain and programme-specific programmes

Government-led skills initiatives are designed to address identified skills shortages.

With the loss of design and manufacturing skills for critical defence products identified by the DoD as a threat to the health of the DIB, the DoD has established a number of skills initiatives in order to address these.¹⁶⁰ The DoD has also identified current workforce demographics as a considerable issue that will need to be addressed in order to prevent future defence skills shortages. As of May 2018, 39 percent of the defence workforce was under the age of 45. Furthermore, only 1.5 per cent of those in the 25 to 35 age bracket were found to hold a science degree.¹⁶¹ This has resulted in a shortage of qualified workers needed to meet current demand, as well as a future workforce that may lack the adequate skills needed to replace senior engineers and technicians as they reach retirement.¹⁶² In response to these challenges, the DoD has launched a number of initiatives designed to develop manufacturing and broader STEM skills within the future workforce. These initiatives have included programmes to increase the number of STEM-oriented students in schools (for example by aiming to introduce 100'000 new STEM teachers into schools by 2020);¹⁶³ supporting internships and fellowships to encourage the uptake of manufacturing careers amongst college students; and providing the current workforce with training in advanced manufacturing.¹⁶⁴

The DoD places strong emphasis on collaboration and public-private partnerships

The DoD actively encourages partnerships between the various entities that make up the Defence Industrial Base (DIB), such as industry, Government bodies, federally funded research and development centres (FFRDCs) and academic institutions.¹⁶⁵ The DoD has identified this approach as an important means for maintaining the critical skills required to achieve US technological superiority.¹⁶⁶ The DoD works closely with industry and higher education establishments in order to identify critical workforce gaps and establish programmes to address these.¹⁶⁷ This collaboration occurs through a number of

¹⁶⁰ Department of Defense (DoD). 2018. 'Fiscal Year 2017: Annual Industrial Capabilities'. As of 23rd October 2018: <https://www.businessdefense.gov/Portals/51/Documents/Resources/2017%20AIC%20RTC%2005-17-2018%20-%20Public%20Release.pdf?ver=2018-05-17-224631-340>

¹⁶¹ Mehta, Aaron. 2018. 'America's industrial base is at risk, and the military may feel the consequences'. Defense News. As of 23rd October 2018: <https://www.defensenews.com/pentagon/2018/05/22/americas-industrial-base-is-at-risk-and-the-military-may-feel-the-consequences/>

¹⁶² Ibid.

¹⁶³ Department of Defense (DoD). 2016. 'Department of Defense STEM Strategic Plan FY2016 – FY2020'. As of 23rd October 2018: https://www.acq.osd.mil/rd/publications/docs/DoD_STEM_Strategic_Plan_2015_1022_final.pdf

¹⁶⁴ Department of Defense (DoD). 2018. 'Fiscal Year 2017: Annual Industrial Capabilities'. As of 23rd October 2018: <https://www.businessdefense.gov/Portals/51/Documents/Resources/2017%20AIC%20RTC%2005-17-2018%20-%20Public%20Release.pdf?ver=2018-05-17-224631-340>

¹⁶⁵ Ibid.

¹⁶⁶ Ibid.

¹⁶⁷ Ibid.

channels including one-on-one meetings between DoD officials and leadership of large, medium and small defence companies, quarterly roundtable meetings between the DoD, industry associations and defence companies. Roundtable participants in 2017 included: DoD leadership; representatives from the Aerospace Industries Association (AIA) and the National Defense Industrial Association (NDIA); and Human Resources executives from Boeing, Lockheed Martin, Northrop Grumman, Price Waterhouse Coopers, Rolls Royce and Elbit Systems.¹⁶⁸

The US has a number of mechanisms in place to facilitate and enhance skills collaboration across the defence sector. For example, the Manufacturing and Industrial Base Policy office (MIBP) has a dedicated Industry Outreach (IO) team, the purpose of which is to enable greater engagement between government and industry to support industrial base initiatives such as those relating to workforce development.¹⁶⁹ The MIBP is the principle advisor to the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics for areas relating to DIB policies and budget matters, and anticipating and closing gaps in industrial capabilities. High levels of collaboration can also be observed at the state level, involving close partnerships between schools and higher education establishments, state governments and industry. These regional partnerships are discussed in more detail in the following sections.

The prevalence of local and regional programmes allows defence companies to influence the development of the local workforce in line with their skills requirements.

Many US defence companies work closely with local skills providers such as schools and colleges in order to access the skilled workforce needed to meet their programme requirements. These initiatives are usually clustered in areas with high levels of industrial activity, such as around shipbuilding yards in Alabama, Virginia and Mississippi.¹⁷⁰

Austal USA has a large shipbuilding facility in Alabama and has a subsequent need for a skilled local workforce. The company has therefore led the implementation of relevant training into local high school curricula to ensure future access to a skilled workforce, through initiatives such as the Mobile County Maritime Academy.¹⁷¹ High school students in Alabama also have access to the Alabama Industrial Development & Technology (AIDT) Maritime training programme, which offers short courses in maritime-specific skillsets such as welding and marine design, to prepare students for employment in the maritime sector.¹⁷² Elsewhere, General Dynamics Electric Boat delivers a pre-employment training course at its welding facility in Mississippi, in partnership with Mississippi Gulf Coast Community College and

¹⁶⁸ Department of Defense (DoD). 2018. 'Fiscal Year 2017: Annual Industrial Capabilities'. As of 23rd October 2018: <https://www.businessdefense.gov/Portals/51/Documents/Resources/2017%20AIC%20RTC%2005-17-2018%20-%20Public%20Release.pdf?ver=2018-05-17-224631-340>

¹⁶⁹ Ibid.

¹⁷⁰ (Industry webpage) AIDT Maritime Training Centre. N.d. 'Maritime Training Centre'. As of 23rd October 2018: <https://maritime.aidt.edu/>; Mobile County Public Schools. 2018. 'Maritime Academy'. As of 23rd October 2018: <http://williamson.mcs.schoolinsites.com/?PageName=bc&n=215759>

¹⁷¹ Mobile County Public Schools. 2018. 'Maritime Academy'. As of 23rd October 2018: <http://williamson.mcs.schoolinsites.com/?PageName=bc&n=215759>

¹⁷² (Industry webpage) AIDT Maritime Training Centre. N.d. 'Maritime Training Centre'. As of 23rd October 2018: <https://maritime.aidt.edu/>

the State Government.¹⁷³ This programme provides one example of effective collaboration between industry, government and academia at the state level.

The US defence industry makes effective use of regional hubs for skills development

Between 2012-2016, the DoD established eight regional manufacturing hubs (Manufacturing USA institutes). The institutes serve as centres of excellence designed to accelerate innovation and develop the skilled manufacturing workforce.¹⁷⁴ Federal investment in the institutes was matched by funding from industry, academia and State governments. As of March 2018, approximately 1200 companies, universities and government agencies have participated in this network of regional hubs.¹⁷⁵ The impact of these regional hubs can be evaluated based on level of participation: 191,877 individuals participated in education and workforce development programmes led by the institutes in 2017 alone.¹⁷⁶ A further 4,302 members of the existing workforce completed a certification or training programme led by the institutes.¹⁷⁷

Another example of the use of regional hubs is Centres of Excellence designation awarded to institutions and municipalities with a strong track record in emphasising cyber security and promoting cyber skills development amongst the future workforce.¹⁷⁸ Fourteen of these Centres of Excellence are located throughout the country, and are supported by the CyberPatriots programme. For more information on the CyberPatriots programme, see Box B..

B.3.3. Cyber skills are a key focus area for US Defence

Federal agencies in the US have launched a number of initiatives designed to train and recruit cyber professionals. These initiatives include military career programmes, developing new recruitment and training programmes for government agencies, and national and state-level youth engagement programmes.¹⁷⁹ The DoD has been recognised as particularly strong in the area of cyber skills development; the Government Audit Office has identified the DoD as one of only two US agencies with a dedicated, cyber-specific workforce planning strategy (the other being the Department of

¹⁷³ (Blog post) Area Development. 2018. 'General Dynamics Electric Boat Plans Major Expansion at Groton, Connecticut, Facility'. As of 23rd October 2018: <http://www.areadevelopment.com/newsItems/5-1-2018/general-dynamics-electric-boat-groton-connecticut.shtml>

¹⁷⁴ Department of Defense (DoD). 2018. 'Fiscal Year 2017: Annual Industrial Capabilities'. As of 23rd October 2018: <https://www.businessdefense.gov/Portals/51/Documents/Resources/2017%20AIC%20RTC%2005-17-2018%20-%20Public%20Release.pdf?ver=2018-05-17-224631-340>

¹⁷⁵ Ibid.

¹⁷⁶ National Institute of Standards and Technology (NIST). 2017. 'Annual Report: Program Report and Summary of Institute Activities'. As of 23rd October 2018: <https://nvlpubs.nist.gov/nistpubs/ams/NIST.AMS.600-3.pdf>

¹⁷⁷ Ibid.

¹⁷⁸ Industry webpage) Cyber Patriot. N.d-a. 'Centres of Excellence'. As of 23rd October 2018: <https://www.uscyberpatriot.org/about/centers-of-excellence>

¹⁷⁹ Silfversten, E., Flint, R., Lynch, A., Ward, A. & A. Hall. Forthcoming (2018). *Cyber Defence Specialist Models (CD SpecMods)*. Prepared for the European Defence Agency. Reference: 17.CAT.NP3.081. Not for public distribution.

Transportation).¹⁸⁰ Boxes Box B.7 and Box B. provide some illustrative examples of cyber skills development programmes currently underway in the US.

Box B.7 Hacking for Defense

Hacking for Defence (H4D) is a flagship DoD programme that partners university students with the DoD to address cyber security problems. The course uses a ‘flipped classroom’ approach, matching teams of students with real-world cyber security problems; over the course of the semester, the students work with DoD entities to explore and develop solutions to the problem.¹⁸¹ Upon completion of the course, students pitch their proposed solution to a DoD sponsor to determine whether this original solution can be turned into a new dual-use venture. While the primary focus of the programme is to foster skills development rather than new venture formation, as of 2017 a number of ventures were generated in this way, some of which have already generated significant capital funding to support dual-use cyber solutions. As of Spring 2018, the H4D programme is being offered at 11 universities across the US;¹⁸² this number is expected to rise to 18 by 2019.¹⁸³

Source: RAND Europe

Box B.8 CyberPatriot

CyberPatriot is a DoD-sponsored National Youth Cyber Education programme created by the Air Force Association (ASA).¹⁸⁴ The programme aims to attract school-age students to a career in cyber security or other STEM-related fields.¹⁸⁵ A number of initiatives are run through the CyberPatriot programme, such as the **National Youth Cyber Defence Competition (NYCDC)** and **AFA Cybercamps**.¹⁸⁶

The **NYCDC** is the central initiative of CyberPatriot.¹⁸⁷ The competition places school students in a set of simulated circumstances in which they must manage the information security of a small company and overcome various cyber security challenges.¹⁸⁸ Teams are given the opportunity to compete at the national level, with the winning team receiving national recognition and scholarship money.¹⁸⁹ Meanwhile, **AFA Cybercamps** provide students with the opportunity to apply their knowledge of cyber security principles in

¹⁸⁰ US Government Accountability Office (GAO). 2011. ‘Cybersecurity human capital: Initiatives need better planning and coordination’. As of 23rd October 2018:

<https://www.gao.gov/new.items/d128.pdf>

¹⁸¹ Department of Defense (DoD). 2018. ‘Fiscal Year 2017: Annual Industrial Capabilities’. As of 23rd October 2018: <https://www.businessdefense.gov/Portals/51/Documents/Resources/2017%20AIC%20RTC%2005-17-2018%20-%20Public%20Release.pdf?ver=2018-05-17-224631-340>

¹⁸² Ibid.

¹⁸³ (News article) Cebul, Daniel. 2018. ‘More universities to offer Hacking for Defense program’. *Fifth Domain*. As of 23rd October 2018: <https://www.fifthdomain.com/workforce/education-training/2018/04/03/more-universities-to-offer-hacking-for-defense-program/>

¹⁸⁴ (Industry webpage) Cyber Patriot. N.d-b. ‘What is Cyber Patriot’. As of 23rd October 2018: <https://www.uscyberpatriot.org/Pages/About/What-is-CyberPatriot.aspx>

¹⁸⁵ Ibid.

¹⁸⁶ Ibid.

¹⁸⁷ Ibid.

¹⁸⁸ Ibid.

¹⁸⁹ Ibid.

a practical environment. The camps are designed to target students at different ability levels, with Standard camps focusing on basic introductory concepts and Advanced camps involving more complex concepts.¹⁹⁰

The impact of the CyberPatriot programme is evidenced through its sustained growth in participation. For example since its inception in 2009, the **NYCDC** has experienced a year-on-year growth of 20% per annum.¹⁹¹ The **AFA Cybercamps** were launched in 2014 in response to demand from schools and students for education opportunities outside the **NYCDC**, indicating that the programme has so far succeeded in generating high levels of interest in cyber security within the future workforce.

Source: RAND Europe

¹⁹⁰ Ibid.

¹⁹¹ (Industry webpage) Cyber Patriot. N.d-c. 'Impact'. As of 23rd October 2018: <https://www.uscyberpatriot.org/about/impact>

Annex C. Overview of key EU-level policies relevant to defence skills

The progression of key developments on the EU policy level is captured in Table C.1 below.

Table C.1 Overview of key selected EU-level policies

Year	Title	Description
2007	Adoption of Defence Package	Defence package included a Communication on 'Strategy for a stronger and more competitive European defence industry' that stressed the need for regulation at EU level, specifically Directive 2009/43/EC on transfers of defence-related products in the EU; Directive 2009/81/EC on Defence and Security Procurement.
2013	European Commission's Communication 'Towards a more competitive and efficient defence and security sector'	Proposals to strengthen internal market and support defence and security industries' competitiveness, including by: a) promoting future-critical skills within the industry through 'Sector Skills Alliances' and 'Knowledge Alliances' and b) urging the Member States to make use of the European Social Fund (ESF) to fund re-skilling and skills matching projects aimed at mitigating the negative impact of restructuring and demand downturn in the defence industry.
2013	European Council Conclusions	Reinforced the need to strengthen the European defence technological and industrial base (EDTIB), stimulate jobs and innovation and develop the necessary skills for the future of the European defence industry ¹⁹² and addressing skills mismatches.
2014	European Commission report 'A New Deal for European Defence Implementation Roadmap for Communication; Towards a more competitive and efficient defence and security sector'	Sets out the implementation roadmap for the 2013 Communication, committing to: a) clarify instances in which European Structural and Investment Funds (ESIF) can be used to support dual-use projects and encourage using it for training and re-skilling needs of the defence industry; b) launch a communication campaign on EU funding opportunities for skills-related initiatives; and c) launch a study on current and future defence industrial key skills and competencies (this was commissioned by the EDA in 2015, with RAND Europe conducting the study ¹⁹³)

¹⁹² European Council. 2013. 'Conclusions of the meeting of the European Council 19/20 December 2013'. As of 21st December 2018: http://www.europarl.europa.eu/meetdocs/2014_2019/documents/sede/dv/sede110914ecconclusionscsdp_/sede110914ecconclusionscsdp_en.pdf

¹⁹³ Retter, Lucia, Louise Taggart, and Jon Freeman. 2015. *Key Skills and Competences for Defence: Annex E*, European Defence Agency, RR-1226-EDA. As of September 26, 2018: https://www.rand.org/pubs/research_reports/RR1226.html

2015	Progress Report on European Commission Communication	Describes those objectives set out in the 2013 Communication which have been achieved, and states the Commission's intention to use the results of the 2015 EDA-commissioned RAND Key Skills and Competencies for Defence study to support the use of existing tools (e.g. ESIF funding)
2016	New Skills Agenda for Europe/ Blueprint for Sectoral Cooperation on Skills ¹⁹⁴	Urges Member States to address workforce skills mismatches, and launches the Blueprint for Sectoral Cooperation on Skills, with defence as one of the pilot sectors. As such, the Blueprint aims to foster strategic stakeholder cooperation in the defence sector to identify and address sector-specific skills gaps.
2016	European Defence Action Plan (EDAP)	Declares the Commission's intention to support stakeholder cooperation in the defence sector through the Blueprint (above) to address skills challenges, including through formulating a sector-specific skills strategy (of which this report and ongoing RAND-led project is part) and making COSME and Erasmus+ instruments available to fund pilot projects (see Error! Reference source not found.).

Source: RAND Europe analysis (2018)

¹⁹⁴ European Commission. 2017d. 'Blueprint for Sectoral Cooperation on Skills : Responding to Skills Mismatches at Sectoral Level.' As of 28 September 2018: <http://ec.europa.eu/social/main.jsp?catId=1415&langId=en>

Annex D. Detailed breakdown of educational and training programmes supporting skills development in Europe

This annex presents a qualitative mapping of educational and training programmes supporting the various stages of skills development in Europe. Divided broadly into ‘top-down’ (those referring to public educational programmes, national strategies, policies and initiatives on skills, which may be both academic and vocational in nature) and ‘bottom-up’ (industry-initiated skills activities which may be formal or informal in nature and can also include collaboration with government agencies or the education institutions) initiatives, the following sections explore in detail the nature and focus of existing educational and training programmes. The annex also presents the ways in which skills development is assessed and measured. The final section considers how companies and national governments invest in skills and keep skills current and future-proof in order to ensure alignment of skills with technological development.

Any statements not specifically referenced in this chapter reflect the findings of RAND Europe stakeholder engagement (expert interviews and workshops with EDSP members). Insights obtained during the interviews are integrated throughout the report and the interview protocol can be found in Methodologies Annex.

Box D.1 Mapping of educational and training programmes supporting skills development in Europe – summary

- Existing top-down initiatives include educational programmes, national strategies, programmes and initiatives on skills
- Most EU MS recognise the importance of skills but few have national policies and strategies on skills
- General or non-defence specific skills are predominantly provided by educational institutions
- In order to ensure transferability of skills, many educational institutions provide dual degrees, therefore integrating non-defence skills in defence education
- Bottom-up initiatives and practices include regional collaborations, industry clusters, and company programmes
- Specialisation and up-skilling is done through specialised programmes, vocational schools, apprenticeships and in-service training
- Collaboration between industry, government bodies, and education sector could help address mismatches between skills provided by the education sector and the industry needs
- National governments use skills anticipation methods to forecast potential changes in the demand and supply of skills, while, specifically in defence industry, Professional Associations provide certification through assessment of degrees and competencies and Defence Industrial Associations provide certification through assessment of examination performance

- Research and Development (R&D) coordination and management is mainly conducted via partnerships between industry and academia, a trend observable across Europe

Source: RAND Europe

D.1. Existing top-down initiatives include national strategies, programmes and initiatives on skills

This section focuses on the supply of top-down skills initiatives in the EU MS, which include educational programmes and national policies, strategies and programmes on skills. These include:

- **National policies and strategies for national defence and security and industry** that consider the role of defence industry in security and economy (e.g. the Czech MOD's Armaments and Defence Industry Development Support Strategy 2025 or Estonian MOD's Defence Industry Policy 2013-2022)
- **Higher education programmes provided by civilian educational institutions**, including dual-use engineering programmes (e.g. the French École Polytechnique and École des Ponts ParisTech specialised in engineering or Paris-Sud University specialised in physics and nanoscience);¹⁹⁵
- **Higher education programmes provided by military educational institutions** (e.g. Poland's Military University of Technology offers degree programmes in chemistry, material engineering, engineering of advanced materials to both civilian and military students as well as a short course on chemical warfare agents);¹⁹⁶
- **Public technical and vocational educational institutions** (e.g. Germany's Bundeswehr University in Munich offers university and vocational college courses in a range of areas, including a defence-specific 'defence engineering' programme);¹⁹⁷
- **Training programmes provided by government-funded research organisations** (e.g. French Alternative Energies and Atomic Energy Commission (CEA)'s Military Applications Division (Direction des applications militaires (DAM) in-house training programme and the UK's Dstl STEM Returners Programme);¹⁹⁸
- **Fora for civilian and military student knowledge sharing** (e.g. Finland's Hackaton, Aalto University);

¹⁹⁵ Geleznikoff, François. n.d. 'CEA: BITDS Francaise: Le Defi du maintien des competences et de l'autonomie strategique.' *Universite Defence*. As of 7 September 2018 : http://www.universite-defense.org/publications/les_position_papers_2017/bitds-francaise-le-defi-du-maintien-des-competences-et-de-l-autonomie-strategique-cea.htm

¹⁹⁶ Military University of Technology. 2018. 'Information for civilian part-time and extra-mural first-cycle studies in the academic year 2018/2019 (from October 2018)'. As of 5 September 2018: <http://www.wat.edu.pl/ksztalcenie/rekrutacja/studia-cywilne-i-stopnia/studia-cywilne-pierwszego-stopnia/>

¹⁹⁷ Bundeswehr University of Munich. 2018. 'Bachelor- und Masterstudium.' As of 18 September 2018: <https://www.unibw.de/bau/studiengaenge/uebersicht>

¹⁹⁸ Geleznikoff, François. n.d. 'CEA: BITDS Francaise: Le Defi du maintien des competences et de l'autonomie strategique.' *Universite Defence*. As of 7 September 2018 : http://www.universite-defense.org/publications/les_position_papers_2017/bitds-francaise-le-defi-du-maintien-des-competences-et-de-l-autonomie-strategique-cea.htm

- **External outreach for elementary and high-school students** that aim at increasing awareness and interest in STEM skills (e.g. the Astronomical Youth Room Research School in Sweden¹⁹⁹);
- **Internet-based training courses provided by national technology centres of clusters** (e.g. Massive Open Online Courses (MOOC) provided by the Finnish Centre for AI and AI and cyber skills courses by the University of Helsinki and Tampere University of Technology);
- **Educational non-for-profit organisations** aimed at practical skills in different areas;²⁰⁰
- **Professional associations' volunteer training programmes** (e.g. the Federation of Occupational Engineer's volunteer training programme in Sweden²⁰¹).

D.1.1. Most EU MS recognise the importance of skills but few national policies and strategies on skills exist

The project team carried out a search for openly available national strategies and policies for skills in the defence sector in a selection of sixteen countries.²⁰² Where such documents were not found, national defence and security strategies and white papers were reviewed to identify the role of the local defence industry in the national defence and economy and scan for any consideration of defence industry skills (see Table D.1 for an overview of these policies).

Overall, while defence industrial skills are often mentioned as an important aspect for the national defence industry or national defence, specific ways of addressing these skills are rarely explicit. Nevertheless, **selected countries such as France, Finland, the Netherlands and the UK have either a defence-specific industrial strategy or other government strategy that singles out the importance of defence industry skills.** Most governments also seek to promote the relationship between the defence industry, defence research and innovation bodies, the armed forces and educational institutions.²⁰³ Governments are motivated to encourage the relationship between the MODs and defence industry due to such factors as the innovation and technical expertise that resides within the industry.²⁰⁴

¹⁹⁹ Space Research School. n.d. 'Space Research School.' As of 27 September 2018: <https://www.astronomiskungdom.se/rymdforskarskolan/>

²⁰⁰ Frivilligutbildning. n.d. 'About voluntary defense organizations.' As of 27 September 2018: <http://www.frivilligutbildning.se/kontakt>

²⁰¹ Ibid.

²⁰² Selected countries include: AT, BE, CZ, DE, DK, EE, ES, FI, FR, IT, LV, LT, NL, PL, SE, and UK

²⁰³ Prime Minister's Office Publications. 2017. 'Government's Defence Report.' July 2017. As of 27 September 2018: https://www.defmin.fi/files/3688/J07_2017_Governments_Defence_Report_Eng_PLM_160217.pdf

²⁰⁴ Ibid.

Table D.1 Level of consideration of defence industry skills in national defence-specific documents

Level	Countries
Countries with national policies/strategies that specifically address defence industry or skills in the defence industry in detail	Czech Republic, Denmark, Estonia, France, Germany, Italy, the Netherlands, Spain, UK
Countries with national policies/strategies that mention the importance of defence industry and/or skills:	Belgium, Latvia, Poland, Sweden
Countries where no explicit defence-industry and industrial skills policies or strategies were identified	Austria, Lithuania

Source: RAND Europe analysis

However, while many of the extant EU MS' national defence industrial strategies may acknowledge the importance of accessing the skills necessary for the defence industry (such as Germany's Aviation Strategy,²⁰⁵ Finnish MOD's Defence and Security Industrial Strategy Report²⁰⁶ or the UK's 2017 Defence Industrial Policy²⁰⁷), they generally do not specify the ways or means to support these skills or the specific skills that should be targeted. Within the European context, the UK may serve as an example of good practice regarding the level of detail of skills requirements included in numerous albeit fragmented governmental strategies. A review of the UK's policies and strategies reveals domain-specific skills requirements that include engineering and systems integrations skills, and design, manufacture and repair skills in the combat air and naval domains²⁰⁸ as well as a set of skills that are regarded as critical and in short supply in the UK: systems and software engineering, project management, mechanical engineering and technicians. UK has also created means of addressing the negative impact of reduced national defence capability demand. For example, the UK's white paper National Security through Technology (2012) recognises the importance of skills both on the demand and supply side, while also considering the defence industrial sector as a vital part of the UK's economy. UK's policies are supported by the establishment of the Skills and Jobs Retention Board in 2010, an industry-led group that aim at helping

²⁰⁵ The German Federal Government. n.d. 'A strong commitment.' 15 June. As of 18 September 2018: https://www.bundesregierung.de/Content/EN/Artikel/2018/06_en/2018-06-15-nato-stoltenberg_en.html?nn=1261110

²⁰⁶ Ministry of Defence of Finland. 2007. 'Defence and Security Industrial Strategy.' As of 27 September 2018: https://www.defmin.fi/files/1151/PUTU_FINAL_in_English.pdf

²⁰⁷ Ministry of Defence. 2017a. 'Industry for Defence and a Prosperous Britain: Refreshing Defence Industrial Policy.' As of 27 September 2018: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/669958/DefenceIndustrialPolicy_Web.pdf

²⁰⁸ Ministry of Defence. 2017b. 'JSP 822 Defence Direction and Guidance for Training and Education.' As of 28 September 2018: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/600177/20170317-JSP_822_Part_1-Final.pdf; Hancock, Matt. 2017. 'The Seven Pillars of the Digital Strategy.' *Address to the Institute of Directors' Digital Strategy Summit*. As of 27 September 2018: <https://www.gov.uk/government/speeches/the-seven-pillars-of-the-digital-strategy>; The Institution of Engineering and Technology. 2017. 'Skills & Demand in Industry: 2017 Survey.' As of 27 September 2018: <https://www.theiet.org/factfiles/education/skills2017-page.cfm>

skilled employees who lost their jobs due to the reduction of defence investment, in other sectors.²⁰⁹ At the same time, the UK has balanced the level of prescriptiveness and specificity regarding the skill and technology areas that to be developed, in have been favouring an approach that is flexible and allows the industry to adjust their priorities considering changes in technology and demand.

The defence skills policy landscape across the EU is shaped by the significance of national DTIBs, the lack of European-level consolidation in most sectors (e.g. except for complex weapons), and by the importance of industry's relationship with national governments. **Most EU countries with medium or large DTIBs consider their national defence industries a significant contributor to national defence** and defence industries are therefore directly or indirectly linked with the national defence concepts and planning. For example, France's government has acknowledged the importance of the defence industry for the country's sovereignty of national defence, by stressing the need to maintain an industrial capacity that enables the capabilities necessary to face a broad-spectrum of threats in its 2017 Defence and National Security Strategy.²¹⁰ While Poland's defence industry may be assessed as medium-sized by comparison, it similarly plays an important role for supplying the state in case of crisis. Considering this, the Polish government plans to invest €30-40 million annually into companies of special economic and defence significance, although it is unclear how much funding will be allocated to skills-specific initiatives.²¹¹

Furthermore, **national defence industries have a substantial place in national economies.** Thus France, the third largest global exporter of arms (after the US and Russia) and hosts several global defence companies, has acknowledged the importance of the defence industry for the country's wider economy and international trade, as well as for the sovereignty of national defence, by stressing the need to maintain an industrial capacity that enables the capabilities necessary to face a broad-spectrum of threats in its 2017 Defence and National Security Strategy.²¹² While Poland's defence industry may be assessed as medium-sized by comparison, it similarly plays an important role for the reindustrialisation and innovation of the Polish economy as a whole. Similarly, the Swedish Security and Defence Association (SOFF) requested government support to safeguard skills in the defence industry and ensure the competitiveness of the Swedish DTIB, which may also contribute to the country's 2017 Total Defence Strategy.

Where domestic defence industry is small, national policies tend to encourage the cooperation of global industrial players with local suppliers (i.e. industrial participation) and use innovative ways of benefiting from the expertise residing within the country, thus encouraging the maintenance and nurturing of local skills and industry. For example, Denmark's industrial defence strategy aims to endorse links between the

²⁰⁹ UK Ministry of Defence. 2012. 'National Security Through Technology.' As of 28 September 2018: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/27390/cm8278.pdf

²¹⁰ Ministry of Defence of France. 2017. Defence and National Security Strategic Review. Bureau des éditions (October).

²¹¹ Poland's Ministry of National Defence. 2017. 'Economy Mobilisation Program.' 10 August. As of 5 September 2018: <http://www.mon.gov.pl/aktualnosci/artykul/najnowsze/bezpieczenstwo-dostaw-sprzetu-wojskowego-na-czas-wojny-82017-08-10/>

²¹² Ministry of Defence of France. 2017. Defence and National Security Strategic Review. Bureau des éditions (October).

national industrial base and the international defence players in order to strengthen its comparatively small defence industry as well as maintaining the industrial skills and capabilities that Denmark considers to be of particular importance for its national defence.²¹³ Estonia is an example of a country that encourages cooperation between the MOD, the industry and academia via working groups to discuss possible solutions to a shared problem set, while also creating an avenue for the national defence industry to reach out to the national armed forces for the skills, expertise and other capabilities (e.g. test ranges and facilities) that may not reside within the industry due to its small size.

D.1.2. General or non-defence specific skills are predominantly provided by educational institutions

While a large number of programmes, specifically ones that are historically established and attract a comparatively large number of students were identified in countries such as Germany, France, UK, as well as Sweden, Belgium, the Netherlands, Spain, Finland Poland, relevant programmes in Lithuania, Italy, Czech Republic were also reviewed. Almost all of the civilian university level programmes receive government funding and cover a broad of STEM skills (including computer science, public procurement and management programmes) while vocational educational programmes funded by the government covered various technical-level skills required in industrial manufacturing, including hardware and software skills. Table D.2 provides a selected sample of non-defence specific or general skills programmes.

²¹³ Erhvervsstyrelsen. 2014. 'Denmark's Defence Industrial Strategy.' 1 July. As of 28 September 2018: <https://erhvervsstyrelsen.dk/sites/default/files/media/den-nationale-forsvarsindustrielle-strategi.pdf>

Table D.2 Indicative overview of the reviewed general (non-defence specific) programmes

Type of managing authority/provider	Funding	Examples of types of programme	Skills covered	Examples
Civilian university	Public or in fewer cases public-public-partnership	BA, BSc, MA, MSc, Specialised masters, level 4 vocational training	Wide range of design, engineering (software and hardware), data science and business engineering skills	
Large commercial enterprise – external	DTIB companies seeking to outsource training	Education and training programmes provided by industry academies	Training in specific industrial (dual-use) skills, incl. technical and soft skills, management skills	Training in design in marine auxiliary systems, risk management in projects, marine propulsions, marine project management provided by Netherlands Maritime Technology Training in aeronautical design with composite materials by Protom, Italy
Large commercial – internal	Industry	Traineeships, internships, short-term training, dual degree programmes, community and talent outreach programmes	Technical, engineering, leadership and production management, marketing and customer relations skills	IABG Advanced training programme for company employees (DE) BAE Systems Schools Partnerships for 14-19 year old students
Military/defence college	Public	Degree-level education programmes	Wide scope, including human resource, engineering, logistics and infrastructure	1st degree education in Information Security at the War Studies University (Poland)
Cluster regions	Public and private	Training programmes	Based on the need of the industrial cluster	Training projects within the Campania Aerospace District in Italy
Other – including technical/vocational schools, SMEs, consortia and other educational establishments	Mixture of government-funded, industry-funded and public-private partnerships	Degree-level education programmes	Mostly more technical competences including computing and engineering	

Source: RAND Europe analysis

D.1.3. Education programmes integrate non-defence skills in defence education

In a number of countries industry-led programmes enable their beneficiaries to benefit from the best of both the academic and industrial worlds. This is due to several programmes being designed and run jointly with academic partners. For instance, in Germany, industry makes widespread use of a dual system of education in its programmes, placing equal emphasis on classroom-based theoretical learning as it does on on-the-job training. Examples of such programmes include a wide array of early-career degree

programmes designed to facilitate a holistic career development and run by companies operating in different domains, such as, Airbus Deutschland, KMW, Lürssen, Rheinmetall, and TKMS.²¹⁴ Similarly, many of the initiatives in place in large French training schools and institutes have been originally initiated by industry. There are also some drawbacks associated with dual education programmes. In particular, companies implementing them are often required to shoulder significant direct and indirect costs. Furthermore, by taking part in academic and educational activities, beneficiaries undergoing such programmes are forced to be away from normal work, potentially during key production phases, even if their long-term productivity may benefit.

D.2. Bottom-up initiatives and practices include regional collaborations, industry clusters, and company programmes

The landscape of bottom-up, or industry-based, skills supply initiatives in the EU MS covers a range of programmes that are described in the Table D.4 below:

Table D.3 Overview of bottom-up programmes and initiatives

Programmes and initiatives	Examples
<p>Cooperation with civilian and military higher educational institutions, including dual-use education programmes, hosting the students of these programmes for the on-the-job training portion of the educational programme. This cooperation may entail different aims, types of cooperation between the industry and educational institution and lengths of on-the-job-training, for example:</p>	
<ul style="list-style-type: none"> • Extensive and established cooperation between the industry and universities and apprenticeships 	<p>Dual degree programmes in business engineering and STEM disciplines supported by such defence manufacturing firms as KMW, Airbus and Rheinmetall in Germany²¹⁵)</p>
<ul style="list-style-type: none"> • Extensive and established cooperation between the industry and high-schools and vocational training institutions, including collaboration on the design of the training programmes and provision of apprenticeships²¹⁶ 	<p>AEROCAMPUS Aquitaine training campus that provides aeronautics training and education for students at the professional baccalaureate-level programme (high-school equivalent), including theoretical and practical training in the aeronautical</p>

²¹⁴ (News article) Dürselen, G. 2018. 'Die Rüstungsindustrie boomt in Zeiten von Kriegen.' *Neues Deutschland*, 15 February, 5:24 p.m. As of 18 September 2018: [https://www.unibw.de/bau/studiengaenge/uebersicht](https://www.neues-; Bundeswehr University of Munich. 2018. 'Bachelor- und Masterstudium.' As of 18 September 2018: <a href=)

²¹⁵ (Industry webpage) Airbus. 2018a. 'Duale Studiengänge.' As of 18 September 2018: <http://company.airbus.com/careers/apprentices-and-pupils/In-Germany/In-Germany-dual-study/schuler-duale-studieng-nge.html>; (Industry webpage) Rheinmetall. 2018. 'Duales Studium by Rheinmetall.' As of 18 September 2018: https://www.rheinmetall.com/de/rheinmetall_ag/career_1/start/dual_study_program/index.php; Federation of German Security & Defence Industry. 2017. 'BDSV.' As of 18 September 2018: <https://fad.di.dk/SiteCollectionDocuments/Materiale%20fra%20industri%20arrangementer/2017-11-23,%20Eksportfremst%C3%B8d%20hos%20KMW%20og%20GDELS/Pr%C3%A6sentation%20af%20BDSV.pdf>

²¹⁶ According to EURES: "Apprenticeships are legally binding and involve a contract. Their duration is clear, as is what you will be learning. They make up part of an education or training programme combining practical, work-

	industry; Italy's Fabbrica d'armi Pietro Beretta arms manufacturer and IPSIA Beretta technical school's "small arms technician course" which includes practical lessons on top of the normal school's curriculum; ²¹⁷ Airbus Global University Partner Programme (AGUPP) in Spain which fosters the development of strategic competences in technical skills in universities ²¹⁸
<ul style="list-style-type: none"> • Internships offered by the industry either in partnership with and educational or training institutions or as a separate industrial initiative. Internships may also allow students to conduct research that is relevant for their thesis or provide recent graduates with relevant work experience which may serve as a path towards employment²¹⁹ 	Sikorsky/PZL Mielec graduate internships in Poland for recent graduates with technical and engineering skills
<ul style="list-style-type: none"> • Traineeships or work placements in defence industry 	Summer traineeship provided by the Finnish firm Patria within different parts of the company and with the possibility for subsequent employment with the company
Education and training programmes carried out by the industry and focus on training potential future employees	Indra's Smart Start Programme for students of computer science, engineering and mathematics, providing training, development and mentorship during the student's first two years at the Indra Corporate university and Indra Open University; ²²⁰ Airbus Minds Programme which practical training and off-line and online courses for young professionals; ²²¹ MBDA's Engineering Graduate Programme in the UK ²²²
Scholarships and monetary awards to students by	PGZ scholarship programme for university students in

related training in the workplace and theoretical education in class. [...] Traineeships can be described as 'work practice'. They give the trainee the chance to log some work experience hours and usually run from a few weeks to six months. There can be a blurred line between a trainee and someone working through their probationary period after having been hired. [...] Unlike apprenticeships they are not linked to recognised qualifications. Internships are usually shorter and frequently carried out by people looking for experience before job hunting. [...] As with traineeships, these are not linked to recognised qualifications." Source: EURES. "Traineeship, internship, apprenticeship – which one is for you?" As of 21 October 2018: https://ec.europa.eu/eures/public/news-articles/-/asset_publisher/L2ZVYxNxK11W/content/traineeship-internship-apprenticeship-which-one-is-for-you-?_101_INSTANCE_L2ZVYxNxK11W_backLabelKey=news.articles.back.to.list&_101_INSTANCE_L2ZVYxNxK11W_showAssetFo

²¹⁷ IPSIA "Beretta". n.d. 'Corso di Tecnico dell'Industria Meccanica Armiera "T.I.M.A."' As of 20 September 2018: <http://www.conarmi.org/media/pdf/Volantino-corso-TIMA.pdf>

²¹⁸ (Industry webpage) Indra. 2018b. 2018b. 'Smart Start.' As of 30 August 2018: <http://www.indraempleo.com/es/smart-start>

²¹⁹ Agenzia Industrie Difesa. 2015. 'Elenco dei bandi di selezione - giugno/dicembre 2015.' As of 20 September 2018: https://www.difesa.it/AID/trasparenza/Documents/Bandi_tirocini/Bandi_espletati/Tabella_proc_selettive_MagDic2015.pdf

²²⁰ (Industry webpage) Indra. 2018b. 2018b. 'Smart Start.' As of 30 August 2018: <http://www.indraempleo.com/es/smart-start>

²²¹ Ibid

²²² (Industry webpage) MBDA. n.d. 'Engineering Graduate Programme.' As of 28 September 2018: <https://www.mbdacareers.co.uk/university-students/engineering-graduate-programmes/>

the industry, including monetary awards to best university undergraduate or graduate thesis of a topic of interest to the defence industry ²²³ or scholarships to university students studying in areas of relevance to the industry	Poland ²²⁴
Industry initiatives aimed at mid-career development as well as specialised up-skilling. These are mid-career development programmes providing more specialised skills and helping, for example achieve specific certifications or qualifications	BAE Academy of Skills and Knowledge providing specialised learning environment for the staff of BAE; ²²⁵ Ficantieri's Corporate university in Italy; ²²⁶ GSG Group Academy of Development providing main production hall technical skills in shipbuilding and operation of mechanised devices, ²²⁷ Swedish Saab's CombiTech Talent programme aimed at mid-career professionals providing business skills
Industry and innovation networks and clusters activities with implication for skills, such as:	
<ul style="list-style-type: none"> Innovation-focused networks and clusters encompassing industry and educational institutions, aiming to exchange of knowledge and support innovation. Industry clusters and platforms that aim to support skills development and transformation are often inspired by technology changes. Skills promoted and developed within such frameworks tend to cover a wider dual-use area than only the ones required for the defence industry 	The Space and Aerospace Cluster in Denmark which supports building knowledge and skills in market and sales competences, tender procedures needed to participate in the European Space Agency (ESA) programmes; France's CampusFab training platform run by a consortium of defence industrial firms and a regional technology-focused competitiveness cluster and focused on the promotion of the skills for the so-called 'factory of the future,' specifically machining, mechanics, manufacturing, maintenance and making industrial professionals more attractive. ²²⁸
<ul style="list-style-type: none"> Skills and innovation hubs in specialised competency areas that aim to facilitate knowledge exchange in a specific technology area at a regional or national level 	Smartare Elektroniksystem (SE) in Sweden, which is an industry-led skills hub encompassing firms working in electronics and cyber. ²²⁹
Industry external outreach programmes mostly seek to increase interest in relevant skills and boost recruitment	
<ul style="list-style-type: none"> External outreach programmes for school students that aim at increasing interest in relevant areas for the defence industry 	STEM 4 Future initiative carried out by Boeing in Italy for pre-high school and high-school students, raising awareness of and interest in STEM skills, ²³⁰ BAE

²²³ Agenzia Industrie Difesa. 2015. 'Elenco dei bandi di selezione - giugno/dicembre 2015.' As of 20 September 2018:

https://www.difesa.it/AID/trasparenza/Documents/Bandi_tirocini/Bandi_espletati/Tabella_proc_selettive_MagDic2

²²⁴ (Industry webpage) PGZ. 2018. 'PGZ to participate in OCEAN 2020 program.' 16 January. As of 5 September 2018: <http://en.pgza.pl/a/707,pgz-to-participate-in-ocean-2020-program>; PGZ (homepage). 2018. As of 5 September 2018: <http://en.pgza.pl/>

²²⁵ (Industry webpage) BAE Systems. n.d. 'Through-career skills development skills 2020.' As of 22 October 2018: <https://www.baesystems.com/en/download-en/20151109161756/1434555689327.pdf>

²²⁶ Unavia. 2018. 'Course catalogue.' As of 20 September 2018: <http://www.unavia.it/formazione/catalogo-corsi/>

²²⁷ (Industry webpage) Gdansk Shipyard. 2018. 'About the Academy.' As of 5 September 2018: <http://www.gdanskshipyard.pl/pl/akademia-rozwoju/o-akademii>

²²⁸ (Industry webpage) CampusFab. n.d. 'CampusFab, pôle d'excellence pour l'industrie de demain.' As of 29 August 2018: <https://www.campusfab.com>

²²⁹ (Industry webpage) Smartare Elektroniksystem. n.d. 'Competency hub.' As of 27 September 2018: <http://www.smartareelektroniksystem.se/insatser/kompetensnav/>

²³⁰ (Industry webpage) Scuolattiva Onlus. n.d. 'Stem 4 Future.' As of 20 September 2018: <http://www.scuolattiva.it/project/stem-4-future/>

	Systems AB Joint Programme with Teknikcollege aimed at boosting technical skills in secondary school students ²³¹
<ul style="list-style-type: none"> • Development and recruitment programmes aiming to attract a specific group of the population 	MTU Aero Engine’s programme in Germany to attract more women to the sector ²³²
<ul style="list-style-type: none"> • Recruitment-focused programmes aimed at attracting more talent and therefore spanning a wide range of potential audiences 	Industry association and cluster partnering with an employment agency, the Adecco Group, to improve recruitment and training in France; SASCORP’s Maker Labs in Leon, Spain, which aims at introducing students to electronics, robotics, programming languages and modern technologies. ²³³
<ul style="list-style-type: none"> • Online skills and talent hubs that disseminate information on skills development opportunities 	Skills.se in Sweden which collects and disseminates information for industry employers and jobseekers not only on vacancies but also on professional development opportunities ²³⁴
<ul style="list-style-type: none"> • Industrial support for government-funded programmes 	Year of Engineering Initiatives in the UK ²³⁵
Private training companies that also provide external training opportunities for EDTIB based on their needs	EC-Council Sweden offers degrees, training and certification schemes in the cyber domain ²³⁶

Source: RAND Europe analysis

D.2.1. Specialisation and up-skilling is done through specialised programmes, vocational schools, apprenticeships and in-service training

One of the most widespread up-skilling strategies is to offer mid-career educational and progression programmes (See Table D.5).

²³¹ (Industry webpage) Bae Systems. n.d. ‘Through-career skills development skills 2020.’ As of 22 October 2018: <https://www.baesystems.com/en/download-en/20151109161756/1434555689327.pdf>

²³² (Industry webpage) MTU Aero Engines. 2016. ‘Human Resources Report 2015/2016.’ As of 18 September 2018:

http://www.mtu.de/fileadmin/EN/7_News_Media/2_Media/Brochures/Staff/Personalbericht_2016_Englisch.pdf

²³³ (Industry webpage) SASCORP. 2018. ‘About: Patronage.’ As of 30 August 2018: <https://sascorp.es/about.html>

²³⁴ Skill.se (homepage). n.d. As of 27 September 2018: <http://skill.se/>

²³⁵ Gov.uk. 2018b. ‘Dstl announces support of 2018’s Year of Engineering.’ 19 January. As of 28 September 2018: <https://www.gov.uk/government/news/dstl-announces-support-of-2018s-year-of-engineering>

²³⁶ EC-Council. n.d. ‘EC-Council Training and Certifications at a glance.’ As of 25 September 2018: <https://www.eccouncil.org/programs/>

Table D.5 Identified examples of specialisation and up-skilling programmes

Type of managing authority/provider	Examples of providers	Examples
Commercial	BAE Systems Academy for Skills and Knowledge; GSG Group Academy of Development	BAE Systems Academy for Skills and Knowledge provided by BAE systems for its staff in the UK. BAE Systems Academy is equipped with technology replicating the equipment used in BAE's manufacturing facilities and engineering labs. The Academy is also a collaborative regional skills hub for cooperation with other industry and academia. GSG Group Academy of Development (Poland) provides technical-level training in welding and work with steel structures.
Military/defence colleges	War Studies University	Degrees that prepare students to work across public administration as well as in the defence aviation industry specifically.
University	Cranfield University	MBA Defence. The course focuses on defence management skills and problem-solving
SME	MAGNA Int	Internships and apprenticeships
Other	Polish Aviation Valley Association	System for supporting aerospace industry by Polish Aviation Valley Association, which also includes support for training

Source: RAND Europe analysis

The reviewed practices revealed the **added value associated with on-the-job experiences that programmes' beneficiaries are able to make through most industry-led programmes**. This holds true for the majority of programmes reviewed with the exception of outreach ones. Examples of on-the-job programmes include:

- Apprenticeships²³⁷ (e.g. the AEROCAMPUS Aquitaine training campus that provides aeronautics training and education for students at the professional baccalaureate-level programme (high-school equivalent), including theoretical and practical training in the aeronautical industry);
- Specialised internships (e.g. Sikorsky/PZL Mielec graduate internships in Poland for recent graduates with technical and engineering skills);
- Traineeships or work placements in defence industry (e.g. summer traineeship provided by the Finnish firm Patria);²³⁸

²³⁷ European Commission. 2018e. "Traineeship, internship, apprenticeship – which one is for you?" As of 21 October 2018: https://ec.europa.eu/eures/public/news-articles/-/asset_publisher/L2ZVYxNxK11W/content/traineeship-internship-apprenticeship-which-one-is-for-you-?_101_INSTANCE_L2ZVYxNxK11W_backLabelKey=news.articles.back.to.list&_101_INSTANCE_L2ZVYxNxK11W_showAssetFo

- Other education and training programmes hosted by the industry (e.g. Airbus Minds Programme which practical training and off-line and online courses for young professionals.²³⁹).

Through better coordination and use of resources, there appears to be scope for **broadening the range of skills supply initiatives on offer with a view to providing more opportunities for mid-career and continuous development**. Also in this instance examples and blueprints to build on exist, such as the BAE Systems Academy of Skills and Knowledge. This academy was designed to provide a specialised learning environment for BAE staff. The Academy is equipped with technology replicating that used in the company's manufacturing facilities and engineering labs in order to continuously upskill the workforce in line with the integration of new technologies and processes into the company. The Academy is also designed to act as a collaborative skills hub for companies across the regional engineering and manufacturing sector with requirements for a skilled STEM workforce.²⁴⁰

D.2.2. Collaborative programmes could help address mismatches between skills provided by the education sector and the industry needs

Industry-led programmes are on average able to **respond in a more agile and dynamic manner to emerging and changing industrial and technological needs** than initiatives designed by public authorities and actors in the education sector alone. The pivotal importance of this was emphasised in the context of what are now rapidly and continuously evolving technological and threat landscapes within which companies and the broader defence establishment are operating. Despite this strength, however, significant gaps are still perceived to exist as regards the availability of skills initiatives tackling new technologies and areas of work (e.g. cyber). With regard to cyber professionals, government employers may appear to have more appealing incentives than the industry due to the opportunity to offer offensive cyber work. This is, however, offset by competition with the civil industries such as financial, telecoms, or private cybersecurity, which is often able to offer better remuneration, flexibility, career progression and various other incentives.

Furthermore, there are opportunities for **building new or reinforcing existing communities to promote peer and social learning of skills and competences**. Similar concepts have been widely used in other contexts to provide a structured approach to social and peer learning. For instance, so-called communities of practice²⁴¹ have been widely used in the fields of evaluation, international development, education, health and healthcare to facilitate multi-professional information and knowledge sharing. Communities of practice can be described as self-organising and self-governing groups of people who share a common concern, a set of problems, or interest in a topic and who come together to fulfil both individual and

²³⁸ (Industry webpage) Patria. n.d.a. 'Konserni ja liiketoiminnat.' As of 18 September 2018: <https://www.patria.fi/fi/ura/konserni-ja-liiketoiminnat>

²³⁹ (Industry webpage) Airbus. 2018b. 'Main Contacts.' As of 27 September 2018: <https://www.airbus.com/contact-us.html>

²⁴⁰ UK Ministry of Defence. 2018. 'Combat Air Strategy.' As of 27 September 2018: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/725600/Combat_AirStrategy_Lowres.pdf

²⁴¹ Wenger, E., McDermott, R., & Snyder, W. M. 2002. *Cultivating communities of practice* (1st ed.). Watertown, MA: Harvard Business School Press.

group goals.²⁴² In the context of skills supply, some learning communities have already emerged through online fora and websites. This is particularly prominent for cyber-related skills, for example, as these are often considered to be better acquired outside traditional university education. The establishment of **skills or innovation hubs that place academia, government and industry in close geographic proximity** could further support the acceleration of knowledge transfer, networking and cooperation between stakeholders to support the development of defence-related skills. The concentration of industry, academic and government stakeholders in the surrounding area of the Gripen defence programme in Sweden, for example, contributed to the flourishing of communities of practice that generated skills spill-overs, which in turn, stimulated the genesis of several start-ups around the area.²⁴³ The Polish Aviation Valley similarly combines local government and defence companies' resources to invest in sophisticated educational hardware infrastructure that allows trainees to work in a learning environment fashioned after a 'mini-defence company,' to support the smooth transition from learning to working.

In France, the Groupement des industries françaises aéronautiques et spatiales (GIFAS) has partnered with Airbus, Dassault, Safran and Thales as well as the French MOD and the Ministry of Employment to develop a skills strategy for the aerospace sector. A number of industry clusters are also pursuing initiatives aimed at enabling new technologies and the 'factory of the future', as outlined in Box D.2 below.

Box D.2 Case study: Factory of the future initiatives

In 2016 **CampusFab**, the training platform for the 'industrial mechanics of tomorrow' was launched in Bondoufle, Essone by a consortium consisting of Safran, Fives Maintenance, GIFAS and Dassault as well as the ASTech Paris-Région competitiveness cluster. CampusFab is part of the Ile-de-France region's 2017-2021 'Smart Industry' strategy.²⁴⁴ It aims to support skills development and digital transformation in French industry.²⁴⁵ Its objectives includes responding to the recruitment needs of industry in **machining, mechanics, manufacturing and maintenance, improving the skills of industry employees and working on making industrial professions more attractive**. Approximately one hundred apprentices and several hundred employees will be trained at the centre annually.²⁴⁶ The campus is expected to open in September 2019.

The Factory Lab is a business hub launched in 2016 by the Paris-Saclay science and technology cluster. A range of industry companies and employment organisations, as well as start-ups, will collaborate on

²⁴² Garrod, Bryn and Tom Ling. 2018. 'System change through situated learning: Pre-evaluation of the Health Innovation Network's Communities of Practice'. *RAND Europe*. As of 23rd December 2018

²⁴³ Keating, Edward G., Irina Elena Danescu, Dan Jenkins, James Black, Robert Murphy, Deborah Peetz, and Sarah H. Bana. 2015. *The Economic Consequences of Investing in Shipbuilding: Case Studies in the United States and Sweden*. Santa Monica, Calif.: RAND Corporation, RR-1036-AUS. As of September 21 2018: https://www.rand.org/pubs/research_reports/RR1036.html

²⁴⁴ (Industry webpage) CampusFab. n.d. 'CampusFab, pôle d'excellence pour l'industrie de demain.' As of 29 August 2018: <https://www.campusfab.com>

²⁴⁵ (Industry webpage) Safran. n.d.b. 'CampusFab, the fabulous campus of the Industry of the Future.' Safran Group. As of 29 August 2018: <https://www.safran-group.com/media/campusfab-fabulous-campus-industry-future-20180618>

²⁴⁶ Ibid.

projects under the framework of The Factory Lab.²⁴⁷ The Factory Lab aims to identify solutions for the needs of industry, with eight initial projects identified with the objective to build practical demonstrators.

Safran is investing in the factory of the future concept, which it launched in 2018. The company has identified the following priority areas in digital transformation: virtual reality, augmented reality, robotics, additive manufacturing, closed door machining and non-destructive testing. It aims to bring together new and traditional elements of industrial manufacturing to leverage their combined potential for efficient production, performance and innovation.

Source: RAND Europe

Industry, government or student-initiated **awareness-raising events, defence career days, hackathons, challenges and prizes** could also support the development of partnerships between stakeholders and attracting talent. Given that most industry programmes are geared at entry-level and mid-career professionals and national programmes are primarily geared at university students, more effective public-private coordination could **support the transition of veterans and other defence organisation personnel to the private sector and skills base**. For example, personnel with experience in the public sector bring great value to the industry, particularly with regard to their understanding of the applications for the industry's products.

The **growth of centres of excellence in game-changing technologies** and **governments' strategic prioritisation of civil industries with strong defence applications** could also attract additional resources, partners and talent to national and industry programmes that supply the defence industry's pool of skills. Industry 4.0 will create demand for STEM skills, skills related to emerging technologies and management staff that specialise in digitalisation. Resources from government or non-defence industry players devoted to support Industry 4.0 could foster access to necessary talent in the defence sector; however, this potential can only be realised if the defence industry is able to offer similarly attractive incentives to talent as in non-defence industries. In Sweden, the growth of autonomous vehicles, graphene, and AI are creating a draw for talent who wish to pursue careers in these novel technologies' leading companies, and the relevance of these sectors to defence could augment the defence talent pool.

However, **incoherence between local and national defence skills programmes and low transparency** over opportunities for collaboration further exacerbate these risks. National programmes that involve industry can help reduce duplication of efforts between stakeholders by launching strategic frameworks and partnerships such as the Defence Growth Partnership in the UK.²⁴⁸ These strategic partnerships could support the focus of stakeholders' efforts and limited resources towards strategic priorities, while benefitting from government's insight on national capability and skills requirements. They could also contribute towards the resolution of bridging issues between skills supplied by public institutions and industry needs. The fragmentation of initiatives and programmes in place stems from both a **lack of**

²⁴⁷ (Industry webpage) The Agility Effect. n.d. 'Saclay is designing the production plant of the future.' As of 29 August 2018: <https://www.theagilityeffect.com/en/article/lusine-du-futur-se-prepare-saclay/>

²⁴⁸ Defence Growth Partnership. 2013. 'Securing Prosperity: A strategic vision for the UK Defence Sector.' As of 27 September 2018: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/237314/bis-13-1154-defence-growth-partnership.pdf

sufficient coordination within industry and between industry and public authorities. Limited coordination between industry and public authorities has negative effects on initiatives led and designed by both stakeholder groups and hampers the overall reach and results produced by both. In some instances, lack of coordination with industry has led to programmes designed by public authorities being disproportionately focused on limited groups of skills and competences, leaving industry alone with the onus to fill in gaps for niche or emerging areas. In turn, industry's efforts are marred by internal sector fragmentation and competition, and by planning of skills supply initiatives taking place in silos. The resulting missed economies of scale that could be reached by pooling and sharing existing resources, lead to a duplication of efforts and, to few or no initiatives existing for several emerging and forward-looking requirements. Fragmentation also affects SMEs, who often lack the resources to sustain skills initiatives alone and that are thus required to either acquire them off-the-shelf from external providers and/or to rely on public authorities support and co-funding.

D.3. How do companies and national governments measure skills development and align skills with new technologies?

The following section explores the ways in which skills development is assessed and measured, aiming to ascertain to what extent national governments and companies understand and use skills anticipation tools (both formal and informal) to forecast and monitor skills. It also considers how companies and national governments invest in skills and keep skills current and future-proof in order to ensure alignment of skills with technological development.

D.3.1. Formal and informal tools and mechanisms to assess skills development and classifications

Although not focused specifically on the defence industry, national governments use skills anticipation methods to forecast potential changes in the demand and supply of skills. Systematic anticipation of skills using both quantitative and qualitative (e.g. scenario-based) techniques can help government decision makers make better-targeted decisions on workforce development and on addressing challenges related to matching the supply and demand of skills.²⁴⁹ Quantitative skills estimates are often based on large-scale multi-sectoral projections to create an understanding of how future economic and technological changes would affect demand for skills.²⁵⁰ Qualitative methods are typically used to complement the aforementioned quantitative techniques. Skills anticipation activities, while unable to result in definite prediction of future skills, may help in making assumptions about future needs, given a framework for systematic, logical and targeted deliberations.²⁵¹ The outcome aims to achieve a more efficient use of the resources available and ensures higher relevancy of educational and training programmes to specific

²⁴⁹ Wilson, Rob. 2013. 'Skills anticipation: The future of work and education'. *International Journal of Education Research* 61. As of 22nd December 2018: https://ac.els-cdn.com/S0883035513000335/1-s2.0-S0883035513000335-main.pdf?_tid=2ed91eb3-0f19-4b59-8abd-85e224076a69&acdnat=1545507003_399c94a93ebcfce4c4d518fc8a9990ea

²⁵⁰ Ibid.

²⁵¹ Ibid.

professions. The literature demonstrates the importance of engaging in skills anticipation activities to prepare for potential future changes in skills demand. Several activities aimed at analysing skills needs, forecasting demand, and labour market trends are conducted in Europe, such as:

- Skills imbalances in the labour market are assessed through trend analysis based on qualitative and quantitative analyses;
- Skills forecasts look at future statistical demand and supply of labour, either in combination with other economic data (e.g. GDP) or through consultation with expert panels;
- Skills foresights looking at sectoral assessments on future labour needs
- Assessment of the relevance of the skills currently pertaining to the workforce (e.g. school leavers surveys);²⁵²
- Skills needs assessments based on surveys of employers;²⁵³
- Dialogues and workshops with key stakeholders.²⁵⁴

The target audience of these assessments are local and national governments, as well as market stakeholders, which proactively establish policies and actions to avoid and/or prepare for skills mismatches, deficiencies or redundancies. Target audiences of the government-level reports include institutions engaged in the governance of vocational education and training, labour market intermediaries, employers and job seekers. Typically, these reports are produced to influence education and training policies, for example by changing curricula, creating new training and education programmes and downsizing ones that are no longer necessary for the economy.

The experience and employment of skills anticipation techniques varies across Europe. In the UK, France, Germany and Sweden, amongst others, skills anticipation practice may be regarded as well established. While some efforts in these countries may still be fragmented, they have invested significantly in skills anticipation to cover broad sectors and regional levels and information is disseminated to a broad range of users.²⁵⁵ In other countries, for instance in the Czech Republic, skills anticipation as a practice has been employed for years and is relatively developed. However, it lacks cohesiveness and coordination among regional and federal initiatives. Estonia, on the other hand, has relatively little experience of skills anticipation, but has recently made significant progress. Skills anticipation is still in development in a number of European countries such as Bulgaria, Croatia, Greece, Hungary and Poland. The European Social Fund has played a significant role in all of the aforementioned countries. For instance, the development and anticipation programmes ‘System of Labour Market Monitoring’ and ‘Future Skills Forecasting’ have contributed to maturity and capacity building in Estonia, Bulgaria, Greece and

²⁵² For instance, see CEDEFOP Skills panorama: Skills Panorama (Homepage). As of 22nd December 2018: <https://skillspanorama.cedefop.europa.eu/en>

²⁵³ CEDEFOP. 2018a. ‘Developments in vocational education and training policy in 2015-17: Poland.’ *Cedefop monitoring and analysis of VET policies*. As of 5 September 2018: http://www.cedefop.europa.eu/files/poland_-_vet_policy_developments.pdf

²⁵⁴ CEDEFOP. 2018c. *Glossary*. As of 11 September 2018: <https://skillspanorama.cedefop.europa.eu/en/glossary/>

²⁵⁵ CEDEFOP. 2018b. ‘Digitalisation and the future of work.’ As of 10 September 2018: <http://www.cedefop.europa.eu/en/events-and-projects/projects/digitalisation-and-future-work>

Poland.²⁵⁶ More specifically applying to the defence sector, the EU MS employ both formal and informal mechanisms of skills development and classification (see Box D.3).

Box D.3 Types of skills assessment mechanisms within EU Member States

<p>Formal Mechanisms</p> <ul style="list-style-type: none"> • Universities and Technical Colleges employ examinations to award official degrees • Joint Industry and Government Programmes provide qualifications using assessment metrics • Professional Associations provide certification through assessment of degrees and competencies • Defence Industrial Associations provide certification through assessment of examination performance • Companies measure skills development using formal competence strategies <p>Informal Mechanisms</p> <ul style="list-style-type: none"> • Companies measure skills development through internal evaluations and use of mentors.

Source: RAND Europe

The most common form of skills development mechanisms applicable in the majority of EU MS are **degrees from universities and technical colleges** that involve the use of formal examinations as a basis for skills assessment. For example, the Bachelor of Management of Defence Technologies at the General Jonas Žemaitis Military Academy of Lithuania awards the qualification based on assessment of student performance. The Centro Universitario de La Defensa, Naval Military School Marin and Universidad de Vigo award the degree in Mechanical Engineering based on examination performance. In addition, there are several instances of Joint Industry and Government Programmes that award qualifications by assessing performance in academic and vocational modules. One example is the UK's Defence Growth Partnership's Systems Engineering Masters Apprenticeship Programme which awards participants a certification recognised across the defence sector and either a post Graduate Certificate, Post Graduate Diploma or MSc in Systems Engineering.²⁵⁷

Professional associations also provide formal assessment mechanisms for skills development throughout a number of EU countries. This often involves a registration process where an individual's skills and qualifications are assessed by reviewers against core competencies, illustrated by the UK Engineering Council and Colegio de Ingenieros de Caminos, Canales y Puertos (College of Spanish Civil Engineers), where engineers request membership through recognition of their degree by the Ministry of Public Works or official approval by the Ministry of Education.²⁵⁸ Skills mechanisms are not within the remit of the vast majority of EU MS Defence Industrial Associations. The Austrian Defence Industrial Association (WKO

²⁵⁶ CEDEFOP. 2018d. 'Poland: developing the Integrated skills strategy.' As of 9 September 2018: <http://www.cedefop.europa.eu/en/news-and-press/news/poland-developing-integrated-skills-strategy>

²⁵⁷ Defence Growth Partnership n.d. 'Skills.' As of 28 September 2018: <https://www.defencegrowthpartnership.co.uk/our-plan/strengthening-industries-capabilities/defence-growth-partnership-skills-team/>

²⁵⁸ Engineering Council. 2018. 'Professional Registration'. As of 22nd December 2018: <https://www.engc.org.uk/professional-registration/>; , European Council of Civil Engineers. 2007. 'Accreditation of European Civil Engineering Programmes'. As of December 22nd 2018: http://www.eccceengineers.eu/activities/education-training/files/45_accreditation_ce_programmes.pdf?m=1508158975&

ADIG), however, is an exception to this. The association provides both a Master's and Proficiency exam in a variety of different trades including shipbuilding and electronic and mechanical engineering.²⁵⁹ The examination is administered through Master examination offices of the chambers of commerce and exam boards in federal states.²⁶⁰

Individual companies measure skills development both formally and informally. Formal examples include Airbus' use of a competence strategy to assess skills and best practices within the company and the International Council of Commerce Consultants provision of Cybersecurity certifications.²⁶¹ Informal mechanisms involve the use of mentors and feedback to track skills progress, demonstrated by Indra's Smart Start Programme which provides graduates with a mentor and feedback every 6 months.²⁶²

D.3.2. Existing efforts and models to coordinate R&D and management with competencies and skills sustainment and development

Research and Development (R&D) coordination and management is mainly conducted via partnerships between industry and academia, a trend observable across Europe. The aim of this coordination is to both transfer and implement future technologies and associated skills from universities to industry, ensuring competitive advantage within the defence industrial base. Box D.4 outlines examples of existing R&D efforts and good practice within Europe.

Box D.4 Existing efforts and models of R&D coordination and good practice

1. Formal Agreements to ensure continuous R&D coordination and management

- Aalto University and Saab's 10 year partnership agreement for developing future technologies including microwave systems and sensor technologies, with opportunities to share space and infrastructure on Aalto Campus.²⁶³
- PGZ signed agreements with various Polish universities to cooperate in R&D sector.²⁶⁴

2. Accessible courses that target students to ensure skills and R&D development

- Free online courses promoting innovation are available at a number of Finnish Universities including University of Helsinki, Aalto University and Tampere University of Technology
- PGZ R&D collaboration with Polish universities includes development of new training programmes and specialisation courses in universities.

3. Transfer of technical knowledge and skills for R&D between partners for skills development and sustainment

²⁵⁹ WKO ADIG (Homepage). As of 22nd December 2018: <http://www.wkoarge.at/en/asw/home/>

²⁶⁰ Ibid.

²⁶¹ (Industry webpage) Airbus. 2018a. 'Duale Studiengänge.' As of 18 September 2018: <http://company.airbus.com/careers/apprentices-and-pupils/In-Germany/In-Germany-dual-study/schuler-duale-studieng-nge.html> ; EC-Council. n.d. 'EC-Council Training and Certifications at a glance.' As of 25 September 2018: <https://www.eccouncil.org/programs/>

²⁶² (Industry webpage) Indra. 2018a. 'Our offices in Spain.' As of 19 September 2018: <https://www.indracompany.com/en/pais/spain>

²⁶³ (Industry webpage) Saab 2018a. 'Saab inaugurates new development centre in Finland.' As of 25 September 2018: <https://saabgroup.com/media/news-press/news/2018-01/saab-inaugurates-new-development-centre-in-finland/>

²⁶⁴ (Industry webpage) PGZ. 2018. 'PGZ to participate in OCEAN 2020 program.' 16 January. As of 5 September 2018: <http://en.pgza.pl/a/707.pgz-to-participate-in-ocean-2020-program>

- Saab's partnership with Aalto is focused on the development of long-term sensor technology, allowing skill transferral between university and industry. The collaboration may also expand into new technology areas, allowing the development of new skills.
 - Navantia's R&D projects involve collaboration with other companies, technology, universities and research centres illustrating transfer of technical knowledge and skills relevant to R&D across sectors.²⁶⁵
- 4. Collaboration between government, industry and academia**
- Navantia's UDC Joint Research Unit involves collaboration between the regional and national Spanish government, University (Universidade da Coruna) and industry. The partnership involves development and transfer of new naval techniques, technologies and associated skills between academia and industry, with government funding, in order to increase competitiveness of the shipyard, one of Spain's central defence industries.²⁶⁶

Source: RAND Europe

As illustrated above, alignment of R&D activity with skills sustainment and development is most successful when it involves collaboration across sectors, such as industry and academia, ensuring transfer of skills and technical knowledge and enabling skills development and sustainment. Whilst the majority of R&D coordination involves partnership between academia and industry, the example of Navantia's UDC Joint Research Unit, which involves funding from the regional government of Galicia and the Ministry of Economy and Business, demonstrates the value government contribution can bring to R&D coordination and efforts. Planned R&D investment increase by several EU governments can provide a greater scope for investment in skill and competency development and sustainment.

²⁶⁵ (Industry webpage) Navantia. 2018. 'R D&I'. As of 22nd December 2018: <https://www.navantia.es/eng/idi/colaboracion.php>

²⁶⁶ UMI (Homepage). As of 22nd December 2018: <https://umi.udc.es/>