

Germany, from *Zeitenwende* to a Defense, Security & Resilience (DSR) Economy

Examining how nations can align innovation ecosystems,
industrial bases and capital markets to build a robust
DSR economy

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Executive Summary

Germany's rearmament over the last four years is dramatic, and holds lessons for other nations especially in the way it mobilizes for the 'defense, security and resilience' (DSR) economy, and thus for more credible deterrence on the European continent. Several dimensions are essential to this shift but one is the 'political will' which had been missing in Germany before 2022, but is now clearly evident. Another, driven by the government, is the obvious (but necessary) provision of the budget, with better pace and procurement. Together, these drive the activation of innovation ecosystems, the industrial base and the capital markets. Alignment of these three systems comes via clearly stated demand signals and strategic prioritization. Germany provides one of the most thorough examples of economy-wide mobilization for DSR in Europe.

Since Russia's full-scale invasion of Ukraine in February 2022, Germany has undertaken one of the most significant reorientations of defense policy, spending and investment in its post-war history, overtaking many European allies in the process. As such, Germany has demonstrated what a nation can do, when it demonstrates clear political will and mobilizes its resources. Starting from a decades-long position of 'strategic restraint' – marked by declining defense investment, an industrial base optimized for stability (not innovation), and deep cultural reservations toward military activity – the speed and scale of Germany's response is, by any historical measure, remarkable.

In a now famous 2022 speech, Germany's then-Chancellor declared a *Zeitenwende* (literally a *changing-of-the-times*) and set the stage for a political commitment to the nation's defense, and wider security and resilience. Despite having misread Russia over its intentions to fully invade Ukraine, over the next four years, Germany's current Chancellor then demonstrated the political will, budget commitment and leadership within NATO to become Europe's largest donor to Ukraine. This fed into the professional *Bundeswehr*, which produced its first full Military Strategy in April 2026, underlining Germany's *Verantwortung für Europa* (Responsibility for Europe) and laying out clear demand-led requirements for strategic military capabilities, defense spending and procurement approaches.

In those four intervening years, the supply of commitment (and capital - in the form of the defense spending budget) as well as the demand for capabilities has been matched by an economy-wide realignment. Germany swiftly reached NATO's 2% spending target for the first time since 1992, restructured its constitutional debt framework to permit sustained DSR expenditure, and has now committed to meeting NATO's revised 3.5% defense and security benchmark by 2029, well ahead of its schedule. As important, the private sector is starting to align to this new opportunity.

An important question is the extent to which, and how, the wider German economy has responded to government efforts during the four years from 2022. And, what lessons can be learned for other nations aiming to build a DSR economy for today's more geopolitically fraught world; one in which DSR capabilities drive both national security and economic prosperity. How do these lessons incorporate not simply 'defence tech' but the extensive set of DSR challenges from defense and security but also resilient industrial systems in communication, energy and manufacturing.

Of particular note in Germany's response, given MIT's framework on 'innovation ecosystems', is that - even before 2022 - the nation possessed many of the foundational capacities and stakeholders required to establish leading innovation ecosystems focused on defense, security, and resilience innovation: a diversified deep tech entrepreneurial base, world-class research institutions, and some (limited) early-stage risk capital. German government commitment built on this foundation, alongside a handful of forward leaning corporates, to help produce a growing

cohort of Innovation-Driven Enterprises (IDEs), i.e. highly ambitious, venture-based companies including Helsing, Isar Aerospace, Quantum Systems, ARX Robotics, and Hypersonica.

It's not, however, simply about start-ups and budgets: Germany's contemporary response to DSR threats increasingly depends upon scaled manufacturing of all the necessary components and systems. These capabilities rarely emerge from start-ups alone and, as Germany has demonstrated, legacy industrial structures have a part to play. This wider 'industrial base' - including prime contractors and smaller sub-contractors (like SMEs in Germany's *Mittelstand*), with a talented, often unionized workforce - has been crucial and is stepping up to meet the moment.

There is a third system that is essential to building a DSR economy - namely a full capital stack to support investment, taking ideas from inception to industrial scale impact. This includes the growing venture capital (VC) sector's response - with European investors including Lakestar Resilience (as an early mover), but also the banking system considering later-stage equity, debt structures, infrastructure finance etc. While not as well developed as other system elements - indeed start-ups still find it a challenge to get banked, and the supply chain struggles to get debt financing for expansion - the capital stack is slowly moving.

It is only when these three systems are activated and linked that a scaled and effective response is possible to a government's political (and budgetary) commitment to DSR and to its prioritized demand signals. Lastly, effective DSR economies rely upon a government's ability to link supply and demand by driving coordinated action toward rapid, efficient demonstration, procurement and adoption.

Beyond budgets: German lessons on how nations can mobilize and rearm

Our analysis (summarized below) evaluates Germany's response around three interconnected systems (namely innovation ecosystems, industrial base, and capital stacks), and then considers three market-making elements (supply, demand and coordination).

Germany has played a leading role in building and connecting its three interconnected systems:

- First, Germany has a series of specialized regional innovation ecosystems that have strengthened and sharpened the focus of entrepreneurs and investors on DSR opportunities – notably Munich (Upper Bavaria) but also Kiel (North Coast) and the Rhineland/ Ruhr area. These are now among the most vibrant in all of Europe.
- Second, there has been a marked reorientation of the nation's traditional defense Primes and wider industrial base toward innovation, collaboration (with start-ups) and investment in scaled production. The existing *Mittelstand* has been activated by the *Zeitenwende* in spite of the traditional reluctance of many to engage in the DSR sector.
- Third, there has been a (slow) expansion of Germany's capital markets into what has previously been regarded as an uninvestable category. However, this remains limited and has been amplified by more rapid capital formation and investment into Germany's DSR economy by international investors.

When it comes to market-making elements (e.g. supply, demand and coordination), Germany presents significant lessons for others, and areas for its own (and others') further development:

- First, it is clear that the *Zeitenwende* has changed the German commitment to defense itself, with a changing political position shifting the supply of political will and the wider stance on defense, security and resilience. This commitment has importantly been matched by increases in meaningful defense spending commitments.

- Second, on the demand side, the German government has provided increasingly clear “demand signals” and has gone some way toward making them a reality, with new contracts not only to traditional Primes but also to start-up innovators from Munich and beyond.
- Third, however, the all important coordination linking market signals to testing and procurement contracts (from government departments) or coordination of market-making policies, remains to be integrated.

Together, these elements of the Germany story provide lessons in a whole-of-society approach toward building a vibrant DSR economy. Starting with the expression of political will at a moment of the 2022 *Zeitenwende* through to the April 2026 publication of the Military Strategy, Germany has translated political statements and strategies into a whole-of-nation transformation with capabilities starting to be delivered to the hands of those in the frontline.

Our analysis offers broader guidance for other nations aspiring to rearm effectively, and for those within their innovation ecosystems, the defense industrial base and capital stacks:

- **First is the essential nature of political commitment.** Germany’s *Zeitenwende* was a statement of intent that served to orient an entire nation, its innovators and entrepreneurs. Other nations must do likewise - as for example Canada’s Prime Minister Carney has done. Alongside the deliberate cultivation of cultural and institutional conditions that legitimize defense, such a commitment supports the lifting of wider normative (and legal) constraints that otherwise limit dual-use research and entrepreneurship supporting the DSR economy.
- **Second is the shift in budget to allow for credible defense spending** as a necessary (but not fully sufficient) condition on the supply-side leading Ministries and other demand-side actors to define and prioritize their capability requirements against their budget i.e. their clear defense investment plan. In Germany’s case, this came in the form of the Military Strategy but many other nations continue to lag in defining priorities.
- **Third is the continued importance of procurement reform to shape demand and define demand signals.** Germany is starting to procure small, low-cost, high-volume systems, and commercial solutions even while it continues to buy large platforms as well. At present however, the nation still lacks the necessary pace and commercial attitude toward the DSR market. Other nations must continue putting in the meaningful effort to change procurement systems to drive rapid purchasing, especially from start-ups and SMEs.
- **Fourth is the role of innovation ecosystems.** Germany had several pre-existing innovation hubs - most importantly Munich but also Berlin – and is actively expanding them as sources of ‘innovation-driven entrepreneurial’ start-ups, which in the light of the *Zeitenwende* shifted even more toward DSR priorities and away from more traditional sectors for entrepreneurship such as digital, consumer, etc.
- **Fifth is the need for continued coupling of DSR innovation to the industrial base.** A few strong champions have stepped in to work with start-ups thus reducing structural market-entry barriers currently favoring incumbent prime contractors. That said, ongoing regulatory and institutional fragmentation limits market access; and coordination among primes, start-ups, and public users remains weaker than the economy (and Germany’s defense) needs.
- **Sixth is the rise of a capital stack** focused on DSR. Germany had some risk capital to support firms in innovation ecosystems from early development, but there continue to be chronic financing mismatches and frictions from complex environmental, social and governance (ESG) considerations, regulation and more general questions of scale-up finance.

The *Zeitenwende* has led to real change, and it provides lessons for other European nations – but it remains unfinished. Germany’s trajectory demonstrates that even deeply embedded structural and cultural constraints can be moved, rapidly and at scale, when political will aligns with fiscal

capacity. Whether that momentum translates into sustained innovation-driven transformation will depend less on spending levels than on Germany's ability to cultivate the ecosystems, institutions, and financing structures that continuously generate, absorb, and scale the next generation of defense, security, and resilience technologies.

Nonetheless, frictions remain and suggest that, while Germany is undergoing a significant fiscal and political rearmament, it has not yet achieved the full potential of a fully scaled innovation-driven *Zeitenwende*. The gap between political/fiscal ambition and transformation of innovation ecosystems and industrial base remains one to bridge. To that end, this paper will explore a new model of the Key building blocks of a national DSR economy (*Figure 1 below*).

Figure 1: Key building blocks of a national DSR economy.

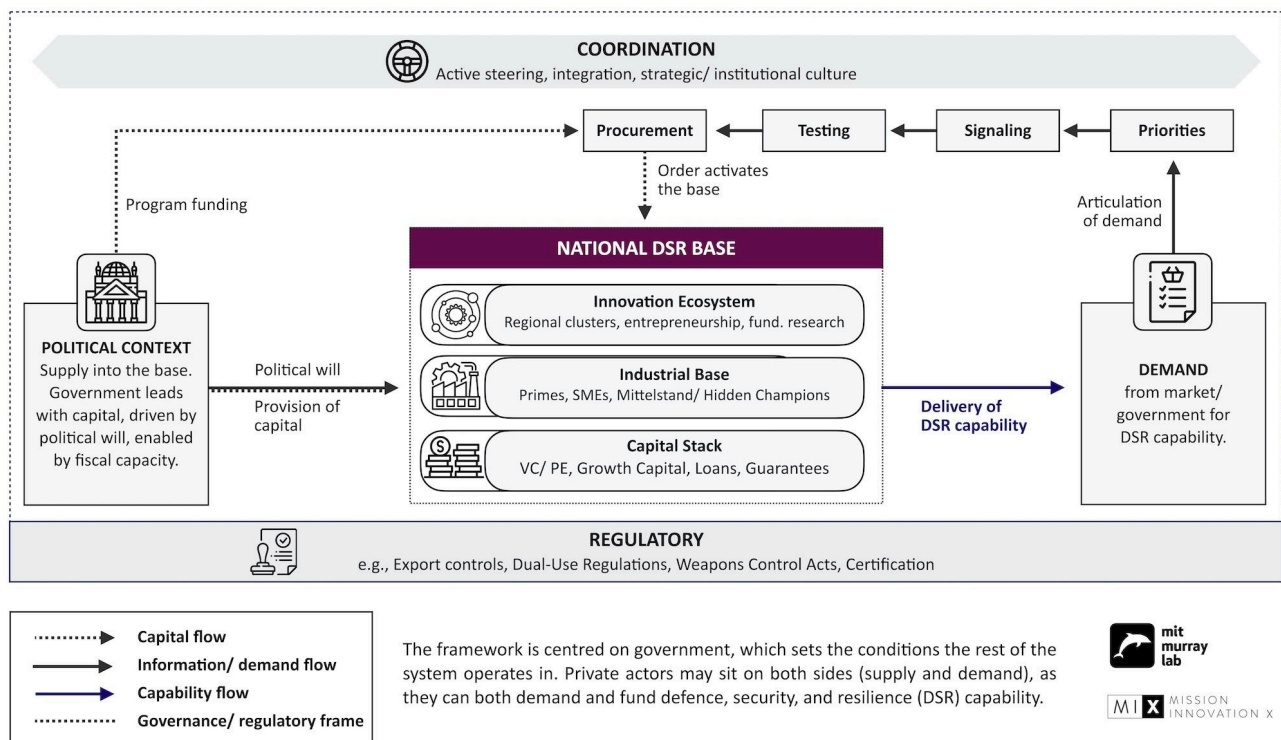


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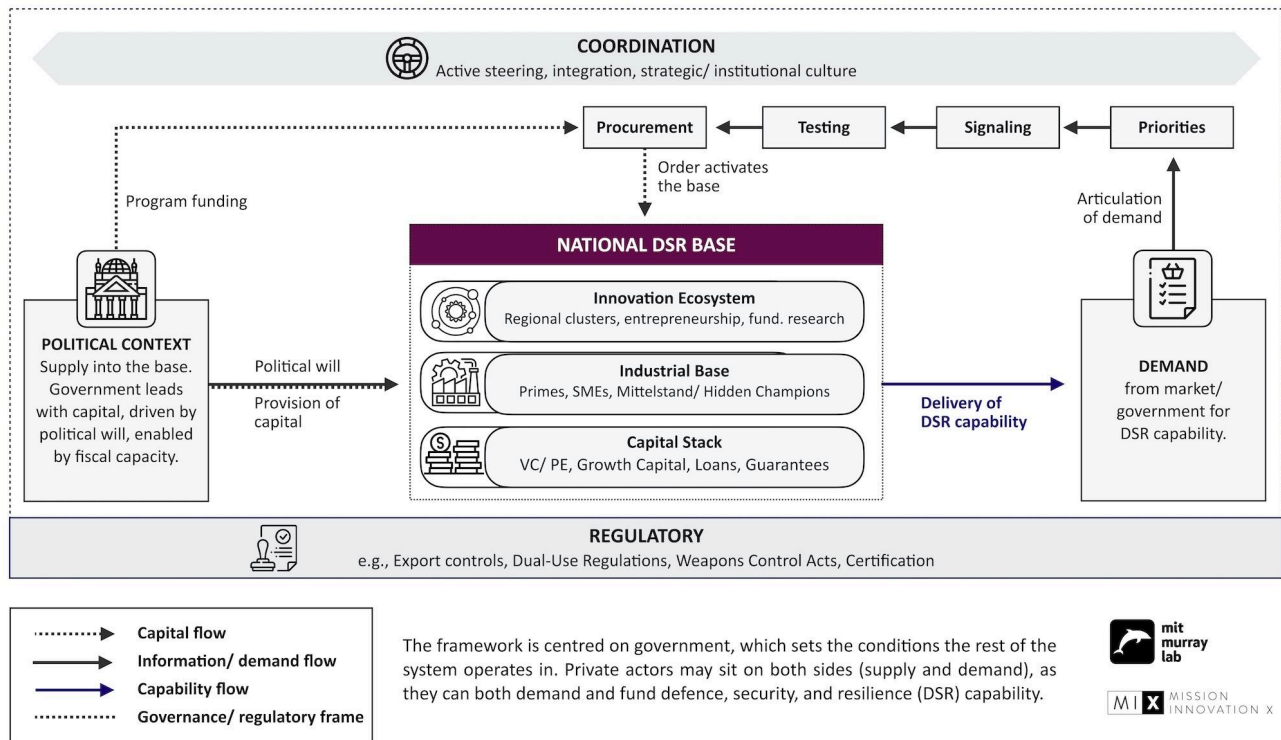
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*This working paper employs a qualitative case study approach to examine institutional and structural dynamics, and stakeholder interactions within Germany's broader DSR economy. The analysis is intended as a structured, interpretive mapping rather than an exhaustive empirical assessment. Desk-based analysis is complemented by experiential insights drawn from two of the authors' involvement in German parliamentary processes (20th Bundestag Defense Committee; 20th Bundestag Research and Technology Assessment Committee), multilateral defense innovation forums, and ongoing engagement at the MIT Murray Lab for Deep Tech & Geopolitics. The paper is circulated to stimulate discussion and invite feedback.

Introduction

Germany's post-2022 transformation is best understood not as a series of discrete policy decisions but as the activation of an interdependent national system. Before turning to the German case in detail, we therefore set out the simple analytical model that structures this paper: a small number of building blocks that, we argue, describe national Defense, Security and Resilience (DSR) economies and make countries comparable (Figure 1).

Figure 1: Key building blocks of a national DSR economy.



At the center of the model sits the national DSR base, composed of three interdependent building blocks: the innovation ecosystem (regional clusters of entrepreneurs, risk capital and research institutions, including fundamental research), the industrial base (prime contractors and the SME supply chain), and the capital stack (venture, growth and private equity, alongside bank credit). None of these blocks functions in isolation: ideas generated in regional ecosystems must be industrialized at scale, and both activities depend on financing that is calibrated to the sector's long development cycles.

The model is deliberately state-centric. Government sets the political context: it leads with capital allocation, driven by political will and enabled by a Treasury's fiscal capacity, and supplies program funding into the base. Private actors, however, may sit on both sides of the model – as suppliers of capability and capital, and as customers in adjacent commercial markets – so the state's task is to lead and orchestrate rather than to monopolize.

On the demand side, requirements travel along a chain from priorities through signaling and testing to procurement. The critical moment is the order: it is the contract, not the strategy document, that activates the base, converting political intent into industrial revenue, production and further investment. Demand articulated by a Defense Ministry (and by the market which defines the shopping list's limitations) thus gives direction to the base; the base, in turn, delivers DSR capability that answers the original demand – a circular relationship rather than a linear pipeline.

Two cross-cutting layers span the entire system. Coordination – the active steering and integration of government, industry, investors and research – determines whether the individual blocks cohere

into a functioning market. Regulation – from industrial export controls to certification, and financial risk mitigation – sets the conditions under which every actor operates.

The analytical claim that follows, and the standard against which Germany is assessed in the remainder of this paper, is that success depends less on the isolated strength of any single building block than on the quality and coherence of the connections among them. Germany, as we show, possesses unusually strong individual components; the *Zeitenwende*'s unfinished business lies in their integration.

Shaping Context: Political Will and Promised Budgets

Russia's full invasion of Ukraine in 2022 drew attention to operational and structural challenges within the German armed forces (*Bundeswehr*), including equipment gaps and persistent weaknesses in procurement. More broadly, these challenges reflect constraints faced by a technologically advanced G7 economy that had invested relatively little in defense over time. Germany's experience raises questions about its capacity to sustain technological sovereignty and credible deterrence in a more contested security environment. Addressing these issues required renewed emphasis on innovation, and the related connection between ambitious private sector entrepreneurs meeting the call of the moment, to the defense-industrial base and capital base.

End of the Cold War, to Russia's full invasion of Ukraine (Feb 2022)

Germany's post-Cold War trajectory can be understood as a prolonged period of reduced military and defense industrial emphasis, unfolding in three broad phases prior to the post-2022 shift.

- **Post-Cold War (the previous *Wende*) Demobilization (1990–1999):** After reunification of West and East Germany at the end of the Cold War, Germany undertook a substantial reduction in its defense commitments. Defense spending declined from 2.5% of GDP in 1990 as the *Bundeswehr* shifted away from territorial defense. Personnel levels fell markedly, from approximately 476,288 soldiers in 1991 to 331,148 by 2000. Reduced domestic demand created a contraction in the defense industrial base, leading to mergers, restructurings, and privatizations. With limited public procurement, the costs of integrating the former German Democratic Republic and weak commercial incentives, research and development (R&D) investment declined, contributing to reduced technological dynamism.
- **Europeanization and Industrial Consolidation (2000–2010):** Through the early-2000s, Germany sought to preserve its industrial capability and global competitiveness (despite the loss of its *Deutsche Mark* currency) through greater European cooperation, partly in response to fragmentation and declining national budgets. The creation of EADS (now Airbus Group) and continuation of multinational programs such as Eurofighter and A400M reflected this shift toward collective production. German firms, including Rheinmetall, expanded toward broader capability portfolios, while MBDA Deutschland and ThyssenKrupp Marine Systems (TKMS) emerged through European and domestic consolidation. These developments professionalized selected industrial segments but also increased reliance on multinational consortia, reducing national control over certain critical systems. This period coincided with a further decline in the defense spending of the unified Germany, reaching a low of 1.1% of GDP in 2005.
- **Conscription Suspended and the Search for Direction (2010–2021):** Throughout the 2010s (under Chancellor Merkel), Germany's defense budget remained broadly stable in real terms, fluctuating only between 1.1% and 1.3% of GDP. Personnel reductions continued: by 2010, active-duty forces had declined to 245,823, a 46% reduction relative to 1990 levels. The suspension of mandatory conscription in 2011 further reduced troop strength to 183,969 by 2021. Although Germany condemned Russia's annexation of Crimea in 2014 and supported EU sanctions, its military response was limited and emphasized incremental adaptation, including participation in NATO's Readiness Action

Plan. Defense firms increasingly relied on export markets, such as Leopard 2 tanks for Gulf states and submarines for Asia, while domestic procurement faced delays and uncertainty. Major programs, including the Puma IFV and the G36 replacement, experienced persistent setbacks, and multinational initiatives such as Eurodrone and Future Combat Air System (FCAS) struggled to gain traction.

2022's *Zeitenwende* – Committing to Defense, Security and Resilience (DSR)

The watershed moment for Germany came in February 2022 with Russia's full invasion of Ukraine which caught the nation by surprise. In response, then-Chancellor Olaf Scholz declared it was a *Zeitenwende*, a turning point, away from the post–Cold War emphasis on the peace dividend toward deterrence, resilience, and closer integration within NATO. To quote at length, [Scholz made a commitment](#), stating:

It is clear that we must invest much more in the security of our country. In order to protect our freedom and our democracy. This is a major national undertaking. The goal is a powerful, cutting-edge, progressive Bundeswehr that can be relied upon to protect us. [...] But we should be under no illusions. Better equipment, modern technology, more personnel – all of this costs a lot of money. We will therefore set up a special fund for the Bundeswehr. [...] We will now – year after year – invest more than two percent of our gross domestic product in our defence.

Beyond political rhetoric and a dramatic call to arms for Germany, Scholz drew on cross-party support (including from the new chairman of the CDU, Friedrich Merz, marking a break from Merkel), and secured agreement to a €100 billion special fund, exempt from the constitutional debt brake and intended to modernize the Bundeswehr and address long-standing investment gaps. As a result, Germany soon reached NATO's 2% defense spending target for the first time since 1992, [spending 2.12% of GDP by 2024](#). In SIPRI's accounting, German military expenditure rose by 28% in 2024 to US\$88.5 billion, the largest in Western and Central Europe, against a European increase of 17%, the steepest since the end of the Cold War (SIPRI, 2025).¹

Over time, these adjustments intensified fiscal and political tensions within Scholz's governing coalition. Following prolonged disputes over budgetary and debt policy, the coalition collapsed on November 6, 2024, shortly after the re-election of U.S. President Donald Trump. The immediate trigger was a budget confrontation between Chancellor Scholz (SPD) and Finance Minister Christian Lindner (FDP), whose subsequent dismissal marked the end of the three-year coalition between the SPD, the Greens and the FDP. Early elections held in February 2025 resulted in the formation of a new government under conservative leadership, with Friedrich Merz (CDU) elected chancellor as the head of a "grand coalition" between the CDU and a diminished SPD. Even before the new government was formally sworn in and following an heated exchange between the U.S. and Ukrainian Presidents at the White House on February 28, Merz secured a cross-party agreement with the outgoing Bundestag majority to leverage Germany's AAA credit rating for rearmament.

This agreement, brokered by Chancellor-designate Merz and secured with the parliamentary backing of the Greens, enabled two major fiscal measures:

- First, a €500 billion infrastructure fund was established for a twelve-year period. Unlike the earlier €100 billion defense fund, this instrument is not earmarked just for military spending but is intended to support broader infrastructure renewal, including transport, digitalization, industrial modernization, and climate-related investments.
- Second, all DSR-related expenditures – including military spending, civil and population protection, intelligence services, cybersecurity, and support for states unlawfully attacked under international law – were exempted from the constitutional debt brake, provided they exceeded 1% of nominal GDP.

¹ The Russian invasion of Ukraine also disrupted core elements of Germany's recent economic model, particularly its reliance on cheap Russian natural gas. The government accelerated energy diversification, fast-tracked LNG infrastructure, and revived debates on strategic resilience. The rapid decoupling contributed to inflationary pressures and exposed vulnerabilities in energy-intensive sectors, notably chemicals and heavy industry, prompting the introduction of energy subsidies and industrial support measures.

In effect, the amendment capped defense spending within the core federal budget at roughly €40 billion (based on 1% of 2024 GDP), while permitting unlimited, earmarked borrowing for DSR expenditures above this threshold. As a result, in [2025, defense spending reached 2.4% of GDP, financed through a €62 billion allocation to the Ministry of Defense and an additional €24 billion from the existing special fund](#).² Following [NATO's decision to raise its core defense spending target to 3.5% of GDP, plus 1.5% for security and resilience, by 2035](#), [Germany declared its intention to meet the core defense target by 2029](#), ahead of the NATO planning horizon, i.e., within the final year of Merz's coalition legal first term.

As the world's third-largest economy (Table A3) and one of the few NATO members retaining an AAA credit rating, Germany is among a small set of allies able to rapidly finance – at least in the short to medium term – a substantial increase in defense spending through sovereign borrowing under relatively favorable conditions. At the same time, the projected trajectory of fiscal expansion, with defense outlays expected to exceed €215 billion annually from 2029 onward, raises questions about long-term sustainability. These concerns are underscored by [Bundesbank projections placing Germany's debt-to-GDP ratio close to 90% by 2040](#). Equally important, absent targeted industrial policy measures, higher spending risks exacerbating price pressures in the defense sector, where capacity constraints, a limited supplier base, and relatively inelastic demand following NATO's spending increase have intensified since Russia's full-scale invasion of Ukraine (Harding, 2026). Yet, the political context has shifted decisively, enabling the government to take a leadership role by mobilizing capital, demonstrating political commitment, and creating the fiscal capacity needed to develop new DSR capabilities.

Significant structural gaps in military readiness and industrial capacity existed in Germany before 2022, despite modest higher defense spending after 2014 (Dorn et al., 2022). The measures adopted since 2022 are significant, particularly given Germany's historical context. Raising headline indicators such as budgets is an essential first step to accompany a broader cultural and strategic shift.

As a whole, these dynamics point to two imperatives. First, the additional debt incurred during rearmament must translate into timely capacity expansion aligned with NATO's emerging 5% capability targets. Second, defense spending should generate durable economic returns, rather than being absorbed by cost escalation. Both objectives hinge on the industrial supply side of the DSR economy. Capacity must be scaled across the industrial value chain to avoid bottlenecks and price pressures. And, novel capabilities cannot rely on incumbent firms alone and instead require that capital is also allocated efficiently to high-growth start-ups and small and medium-sized enterprises (SMEs), where much of DSR technological dynamism is concentrated (Murray et al., 2025).

The post-*Zeitenwende* posture therefore highlights the need to align higher defense spending with strategic investments in both established industrial capacity and IDEs - those ambitious, high growth start-up ventures leveraging previously untapped entrepreneurial ingenuity to meet this historic moment. This focus is critical not only for closing immediate gaps, but also for ensuring that increased outlays translate into sustained economic returns and meet broader NATO readiness and infrastructure commitments. The effectiveness of the German approach to building a DSR economy matters for Germany but also for all NATO allies: the conversion of higher defense spending into tangible defense, security and resilience capabilities aligned with economic growth largely depend on how effectively demand signals are aligned with innovation ecosystems, industrial capacity and the capital stack.

² The fiscal reorientation places Germany at the head of a much larger European movement. Across the EU-27, defense spending rose from €240 billion in 2022 to €343 billion in 2024, with investment spending passing €100 billion for the first time, and an estimated €381 billion in 2025 (EDA, 2025). Even so, the aggregate gap remains large: had European NATO members already met the new benchmark in 2024, they would have needed an additional US\$663 billion, an increase of 146% over actual spending (SIPRI, 2025). At the EU level, the SAFE instrument opens a €150 billion credit frame, and the ReArm Europe plan targets some €800 billion over four years, €150 billion in EU loans plus €650 billion in national fiscal headroom under the loosened fiscal rules (Wolff et al., 2025). Germany's core defense budget line (Einzelplan 14) is set to rise accordingly, from €50.1 billion in 2023 to €82.7 billion in the 2026 draft budget (Bundesrechnungshof, 2025a).

System 1. An Innovation-driven Response to DSR - Innovation Ecosystems

Building a DSR economy driven by innovation is a novel mode of meeting the defense and security needs of our nations. Traditional efforts have rested upon the combination of large defense primes supported by strong SME-oriented supply chains on the one hand, and on the other, government research spending, largely confined to national laboratories (focused on large-scale activities).

Today, taking a leaf out of the shifting structures of our innovation economy, the opportunity to build strong DSR capabilities should rest also on driving private sector ingenuity and innovation-driven entrepreneurship toward our highest DSR priorities. Drawing on lessons from other national priorities such as healthcare, energy and climate protection, the evidence suggests that regional innovation ecosystems are the core engine of innovation-driven growth. However, even Silicon Valley – the world's most iconic innovation ecosystem – rests on broader national (and often international) foundations: an industrial base supported not only by large prime contractors but also by a strong network of SMEs and Mittelstand companies, and a financial base built on a layered capital stack. In pursuit of DSR capabilities, nations must be especially mindful to link their vibrant innovation ecosystems to the wider industrial base and a nationally effective capital stack given the traditional frictions in linking innovation, industrialization and financing in this sector.

Against this backdrop, and in light of the *Zeitenwende*, the emergence of a DSR innovation economy in Germany holds important lessons. Our analysis examines the extent of progress first from the three perspectives noted above:

- i. the degree to which Germany's emerging innovation ecosystems have supported the *Zeitenwende* moment, and the role of new start-ups as a much-needed engine of private sector ingenuity and entrepreneurial pace,
- ii. the extent of change in the defense industrial base, specifically its connection to these entrepreneurial IDEs, and
- iii. the rate at which the regional, national or international elements of the capital stack evolved to meet a changing market.

We then turn to the ways in which the government has created a market for DSR – both through its supply of political will and, most importantly, its shifting market demand for DSR solutions. Viewed through this procedural supply/demand lens, the German experience provides significant insights into the opportunities and challenges of translating political intent into a sustained DSR economy.

Innovation-Driven Enterprises (IDEs) Providing New DSR Capabilities

A close link between innovation and long-term security outcomes is well documented: Al-Rodhan (2018) identifies innovation as a key predictor of sovereign states' stability, while Guéhenno (2024) emphasizes that control over technological advancement shapes both the conduct of warfare and the ability to sustain peaceful societies.

From this perspective, strategic rearmament cannot be reduced to revitalizing legacy military-industrial structures alone but requires engagement across the wider national innovation economy. IDEs – ambitious start-ups with a focus on bringing new technological solutions to market and mission opportunities – are key to that engagement. Unlike conventional SMEs, these IDEs typically pursue global scalability and rely on research-intensive technologies (Aulet & Murray, 2013), introducing new capabilities alongside potential efficiency gains.

Even prior to the *Zeitenwende*, German IDEs were gaining increasing relevance in the DSR space. The expansion of VC, the emergence of tech unicorns, and new public funding instruments had already reshaped Germany's entrepreneurial activities. However, public and political support for the nation's DSR agenda saw ambitious entrepreneurs turn toward defense- and dual-use – and more broadly DSR technologies including solutions relevant to the military, intelligence, and crisis-response domains.

Among the first were software start-ups like Helsing (founded in 2021), which develops AI-driven decision-support technologies for a range of defense applications, including air defense systems such as the Eurofighter, underwater warfare, and drone technologies. Likewise, ARX Robotics (2022) was founded by military veterans to develop autonomous robotic vehicles for military, disaster relief, and aerospace applications. [Polaris Spaceplanes](#), a 2018 German Aerospace Center (DLR) spin-off is developing hypersonic transport platforms. Likewise [Hypersonica](#), which focuses on high-speed propulsion and hypersonic vehicles – an area of rising strategic importance, after the May 2025 India–Pakistan air clash exposed limits of Europe’s conventional aerospace systems.

The war in Ukraine has underscored the operational relevance of such firms, particularly in areas involving emerging technologies such as uncrewed aerial and ground vehicles (UAVs/UGVs) and loitering munitions, where start-ups specializing in hardware/software integration have found new application spaces (Ostafiichuck et al., 2025) and have rapidly scaled as a result, as, for example Tytan Technologies.

Other start-ups have adapted their solutions from other domains for DSR opportunities. For example, [Quantum Systems](#), founded in 2015, develops eVTOL drones and has rapidly expanded production since 2022, including a doubling of its Vector drone deliveries to Ukraine since 2025. It has partnered with ARX Robotics to meet the rising demand for uncrewed systems on modern battlefields. Similarly, [Mynaric](#) (founded in 2009) produces secure laser communication systems for civilian and defense markets. [Donaustahl](#), which originated as a supplier of sports shooting equipment in 2020, today develops loitering munitions with AI-supported targeting. This cohort is part of a wider new [German-European innovation wave](#): more than 230 defense-tech companies have been founded across Europe since 2022, with private investment reaching a record in 2024 – a dynamic the [European Commission's Defence Industry Transformation Roadmap explicitly seeks to harness, naming speed, agility and risk-tolerance as operating imperatives, and SMEs and start-ups as core innovation carriers](#).

While large platforms – such as tanks, combat aircraft, and naval vessels – remain largely within the remit of primes, the defense sector is increasingly being shaped by IDEs. This dynamic is especially clear in AI, sensor systems, and data analytics – domains that are central to modern conflict. Start-ups in these areas often face fewer institutional constraints than established primes, but the development of fully integrated defense systems often positions start-ups as specialized contributors rather than system integrators, thus pointing to a need for IDEs to work alongside and with large Primes as well as the wider industrial base.

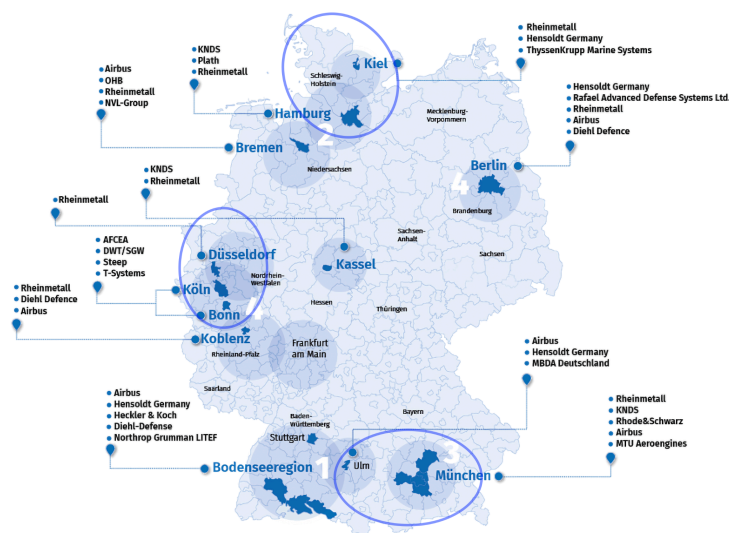
A 2045 battlefield scenario associated with the Franco-German MGCS program (Heiming, 2024) illustrates this complementarity, with autonomous drone swarms operating alongside infantry and armored units through shared data links – an outcome dependent on close collaboration between new entrants and legacy firms. [Helsing](#), for example, is integrating AI into platforms such as tanks, aircraft, and submarines, and partnered with Saab combining highly advanced AI capabilities with the prime’s wide range of products. In early 2026, [the German parliament approved the procurement of loitering munitions, with initial contracts of approximately €270 million each awarded to Helsing and STARK Defence, alongside an option to expand total spending up to €2 billion](#).

NATO’s 2025 collective commitment to raise spending to 5% of GDP aims “[to harness emerging technology and the spirit of innovation to advance our collective security](#),” placing growing emphasis on DSR technology start-ups, or “DSR tech.” Beyond highlighting the broader market potential of many DSR solutions, and the commercial opportunities arising from an increased focus on resilience and technological sovereignty, this shift encourages entrepreneurs in Germany and elsewhere to target sectors such as space launch and Earth observation, where commercial markets’ opportunities are as significant as government/ military ones. [The World Economic Forum projects a global space economy of approximately US\\$1.6 trillion by 2035](#), with defense accounting for a significant share.

Unlike the Cold War's state-led space race, this expansion is driven largely by private IDEs and mixed capital configurations, prompting governments to reconsider how civil and military innovation are integrated (EFI, 2024). For example, Isar Aerospace illustrates this DSR logic. Founded in 2018 by postgraduate students at the Technical University of Munich (TUM), the company develops micro launchers for low Earth orbit (LEO) payloads. Backed by more than €400 million, including investment from Porsche, it primarily targets commercial space markets while attracting interest for defense applications such as rapid satellite deployment. Likewise, TALOS develops compact LEO-operated IoT tag tracking technology for environmental monitoring, supported by public initiatives including the Max Planck Institute's Icarus project.

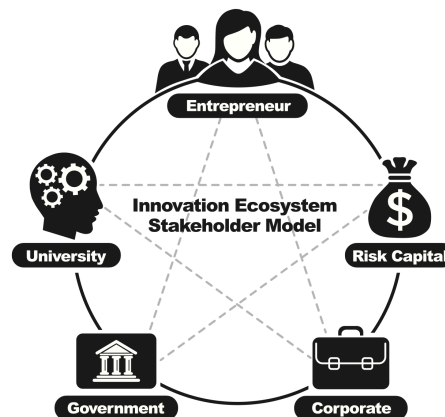
Technological innovation – particularly in deep tech at the scientific frontier, and in applications closely connected to end users – tends to concentrate geographically in what are commonly described as innovation ecosystems (Budden & Murray, 2025). This spatial perspective contrasts with a “flat world” thesis (Friedman, 2005), which assumes innovation can emerge independently of local complementarities. An innovation economy capable of supporting Germany’s post-*Zeitenwende* modernization therefore depends on the development of domestic ecosystems that integrate diverse organizations, allow for entrepreneurial experimentation, and ultimately connect to a scalable industrial base and a wider capital system.

A government-commissioned analysis based on workforce size (Fischer et al., 2015) identifies key DSR concentrations in **Greater Munich** (Bavaria, partly overlapping with Baden-Württemberg), the **Rhineland/ Ruhr area**, and **northern Germany's coastal states** (e.g. Schleswig-Holstein), as illustrated in Figure 2. Interestingly, these regions display differentiated profiles across DSR segments, including comparative strengths in air, land, and maritime systems respectively.



The **MIT Innovation Ecosystem Stakeholder Model** (Budden & Murray, 2025) identifies a range of essential stakeholders who come together to support effective innovation ecosystems (Figure 3). Generalizable across a wide range of sectors and areas of expertise – for example, from Greater Boston's expertise in the life sciences to Los Angeles' emerging ecosystem in space and aerospace – key stakeholders beyond IDEs include risk capital, universities, local corporations, and government entities. Within the context of DSR-focused innovation ecosystems, this includes the presence of Ministries related to defense and national security (most notably with links to frontline military commands), and among corporations, with links to established (defense) primes and other industrial partners. Seen through this lens, a preliminary analysis of Germany suggests three essential DSR ecosystems at different stages of maturity.

Figure 3: The MIT Innovation Ecosystem Stakeholder Model



(Budden & Murray, 2025)

Greater Munich (Upper Bavaria) - Air Systems

- The strongest innovation ecosystem is that in the Munich metropolitan area in Upper Bavaria which emerged as Germany's leading aerospace and defense cluster, with roots in aviation and armaments reaching back to the interwar period. Industrial expansion accelerated during the Cold War, supported by an early semiconductor industry and proximity to U.S. military operations in southern Germany. Munich's role in international discourse has been cemented by hosting the Munich Security Conference since 1963.
- Since the 1990s, the region has evolved into a globally recognized innovation ecosystem, particularly in deep tech, aerospace and cybersecurity. Often referred to as "Isar Valley," Munich and Upper Bavaria combine a strong industrial base with a dynamic start-up ecosystem and have become a major magnet for both domestic and international VC.
- Established defense firms such as Airbus Defence and Space, MTU Aero Engines, and Hensoldt coexist with high-growth technology companies, including Celonis, Helsing, ARX Robotics, OroraTech, and Isar Aerospace. Programmes such as Hensoldt's FCAS Accelerator further demonstrate that the selective integration of start-ups into major defense programs is feasible.
- The regional DSR momentum is actively supported by the CSU-led state government and institutional anchors such as TUM – the EU's leading university –, TUM Venture Labs, and UnternehmerTUM, recognized by the Financial Times as Europe's leading start-up hub. Alongside TUM, Ludwig Maximilian University and the University of the Bundeswehr Munich, which hosts the Palladion Defence Accelerator (NATO DIANA network), contribute to a dense academic environment. More than 65 research institutes operate in the region, including headquarters of the Fraunhofer and Max Planck Societies, the DLR, and a payload operations site for the European Space Agency. Multiple Bundeswehr facilities, including the Bundeswehr Innovation Center, the Bundeswehr Technical Center (WTD) 52 and WTD 61, complete the ecosystem, positioning Upper Bavaria and Greater Munich as a critical node for aerospace innovation and production, and deep tech entrepreneurship.

The Rhineland/ Ruhr area - Land Systems.

- North Rhine-Westphalia's (NRW) Rhineland and Ruhr area, together with parts of neighbouring Rhineland-Palatinate (RLP), constitute one of Europe's historically most significant industrial heartlands. Their legacy in steelmaking and heavy manufacturing provided the foundation for military production throughout the 19th and 20th centuries. After World War II and during the Cold War, the region transitioned into a modern defense hub through technological renewal and the emergence of specialized defense firms. At present, the concentration of IDE start-ups remains limited, although initiatives such as the launch of the DefenseTech-Inkubator.NRW point to considerable potential and public interest.
- Today, the Rhineland's defense and security activities focus on land-based systems, armored vehicles, heavy equipment, and munitions. It hosts leading OEMs such as Rheinmetall, alongside firms active in cybersecurity and aerospace. More than 20% of DAX-listed companies are headquartered in the region. Its central location, close to the Ruhr and Rhine-Main metropolitan corridors, is reinforced by dense transport infrastructure, including highways, rail networks, and major airports such as Düsseldorf, Cologne/Bonn and Frankfurt close-by.
- RLP adds strategic depth through the presence of U.S. and NATO facilities, notably Ramstein Air Base, as well as the Federal Office of Bundeswehr Equipment (BAAINBw), Germany's central procurement agency. Additional military testing sites (WTD 41/51) and Bundeswehr installations further strengthen the regional DSR innovation ecosystem. Research capacity is substantial: together, NRW and RLP host around 90 universities, including leading technical institutions such as RWTH Aachen, ensuring a steady supply of skilled labor.

Northern Germany (Coastal States) - Maritime Systems

- Northern Germany – comprising Schleswig-Holstein, the coastal regions of Lower Saxony and Mecklenburg–Western Pomerania, and the city-states of Hamburg and Bremen – forms the maritime backbone of Germany's DSR landscape. Strategically located between the North and Baltic Seas, Schleswig-Holstein has a long tradition of shipbuilding and naval defense dating back to the 19th century. Naval facilities in Kiel, Eckernförde, and Warnemünde, alongside WTD 71 (Schleswig-Holstein) and WTD 91 (Lower Saxony), underline the region's enduring strategic relevance. Once again, IDEs are limited but with this innovation ecosystem showing potential.
- Northern Germany's research landscape encompasses over 60 universities and institutes, including the Bundeswehr University in Hamburg, the Institute for Security Policy at Kiel University, and the Alfred Wegener Institute for Marine Research.
- The defense and security industry concentrates on naval vessels, submarines, and associated technologies, complemented by R&D in underwater communication, sensors, and cybersecurity. Core industry actors include TKMS, German Naval Yards, and Flensburger Shipyard GmbH, together supporting more than 5,700 jobs in Schleswig-Holstein alone. The global competitiveness of this regional maritime base was underscored in July 2026, when Canada selected ThyssenKrupp Marine Systems as preferred supplier for up to twelve submarines under the Canadian Patrol Submarine Project – the largest defense procurement in Canadian history.
- At the same time, the industrial base is expanding into the protection of underwater infrastructure – an area of heightened importance following attacks on critical pipelines such as Nord Stream I and II. A growing cohort of maritime defense start-ups, often linked to innovation hubs in Hamburg and Bremen, is advancing capabilities in uncrewed underwater systems, AI-enabled sensors, and data analytics.
- The region also plays a central role in allied operations, hosting NATO's Centre of Excellence for Confined and Shallow Waters in Kiel, and the Baltic Task Force Naval Command in Rostock. Its geostrategic position facilitates close cooperation with partners in the Netherlands, Sweden, Denmark, Poland, and the Baltic States.

Ecosystem Coordination - Challenges & Opportunities

Corporate cultures across innovation ecosystems have historically entrenched separation between civilian and military spheres, resulting in [institutional silos, limited collaboration between start-ups and established firms, and underexploited complementarities](#) – even in regional ecosystems that would otherwise offer favorable conditions for cooperation. While comparative ecosystem research suggests that “no one is in charge of innovation” (Guzman et al., 2023, p. 49), the German case reveals a deeper structural weakness. Additional challenges, especially for new entrepreneurial ventures in the DSR sector, arise from Germany’s federal system of local business taxation, which grants municipalities considerable discretion over tax rates. As a result, firm location decisions increasingly reflect fiscal considerations rather than technological complementarities or cluster effects, complicating scaling strategies and cross-regional collaboration.

The three regional clusters (see Table 1 below), through their stakeholders, have developed distinct comparative opportunities that become particularly visible in their track records of cross-stakeholder collaboration, especially between corporates and start-ups.

- In Bavaria, the collaborative pattern has advanced furthest. Taufkirchen-based Hensoldt has both invested in Munich-based Quantum Systems and begun [integrating the start-up’s uncrewed aircraft into its CERETRON sensor-fusion architecture](#), with joint work extending toward FCAS-related sensor architectures. Airbus Defence and Space, in turn, led the Bundeswehr’s KITU2 study on [AI-controlled drone swarms with Quantum Systems at its Manching drone center](#) – feeding results into FCAS- and MGCS-related planning – and in July 2026 [co-led the company’s US\\$1.2 billion financing round](#). The progression from joint experimentation through program integration to strategic investment is precisely the repeatable pathway that other regions can study – and a well-documented example of the role that corporate leadership plays in regional ecosystems (Budden & Murray, 2025). A complementary, government-driven example is the newly established Bundeswehr Innovation Center in Erding, which aims to forge a direct link between start-up procurement processes and this specific ecosystem. Opened in February 2026 and anchored within the BAAINBw, the center is intended to give civilian innovators structured access to military testing, procurement expertise and secure infrastructure at a dedicated Bundeswehr site.
- The Rhineland and Ruhr area shows a different, earlier-stage model. Here, Düsseldorf-based Rheinmetall is teaming up, as general contractor of its [Giga PtX concept for decentralized production of synthetic fuels](#), with the Essen-based carbon-capture start-up [Greenlyte Carbon Technologies](#) – a dual-use energy-resilience case rather than a classical land-systems one, but valuable precisely because it shows a land-systems prime drawing on an adjacent regional cleantech base. Rheinmetall’s joint venture with the Finnish SAR-satellite start-up ICEYE – [Rheinmetall ICEYE Space Solutions, established in Neuss in November 2025](#) and awarded a Bundeswehr space-reconnaissance contract weeks later – follows a complementary localization model, in which the region contributes production capacity and program leadership while the entrepreneurial technology is imported. The company is also a lead supporter of the [Production Launch Defence Centre](#) which focuses on defense technology transfer. Rheinmetall, moreover, established organizational routines for systematic corporate venturing and start-up engagement early on – albeit in its automotive rather than its core defense business (Neumann et al., 2019) – suggesting the capability to replicate such initiatives deliberately across sectors.
- In Northern Germany, by contrast, the most concrete corporate initiatives either point outward or remain institutional. When ThyssenKrupp Marine Systems and Bremen-based ATLAS ELEKTRONIK screened more than 100 start-ups for [maritime-autonomy pilot projects](#), the four companies invited to Bremen came principally from France, Switzerland and Israel. The Defense Ministry’s May 2026 decision to establish a [naval innovation center in Kiel](#), linking the navy, research institutions, incumbents and start-ups, is best read as an attempt to build exactly the interface the region is missing.

Read together, these examples place the three regions at different stages of one development path: Greater Munich has reached investment and system integration, the Rhineland/ Ruhr area is building incubation and industrial-localization capacity, and the north remains at external scouting and institution-building. Effective national coordination would recognize this gradient and design instruments for each stage, rather than average across it.

Alongside corporates and entrepreneurial ventures, universities form another natural axis of ecosystem coordination. Yet those that could, in principle, serve as hubs for education, R&D, and knowledge transfer are often constrained by normative or institutional barriers that raise transaction costs and discourage joint security-relevant projects. The systematic bifurcation between civilian and military research restricts knowledge exchange, suppresses dual-use spillovers, and leads to duplicative structures that slow innovation. Civil clauses and restrictive governance frameworks at many German higher education institutions impose de facto firewalls around defense-related research (EFI, 2024), even in industrial core regions with strong technical capabilities.

However, some regions are instructive in how they have shifted toward more permissive regulatory environments – e.g., Bavaria or Lower Saxony – and are better positioned to integrate security-relevant research into incubators and accelerator programs. In contrast, institutions in more restrictive states remain largely excluded from defense cooperation. This heterogeneity limits universities' ability to act as reliable anchor institutions within regional DSR ecosystems as their role is shaped by state-level – or even institutional – interpretations of civil clauses: where such clauses exclude or severely restrict military research, it is their interpretation at the ecosystem level that determines participation in the DSR economy.

Cross-state variation further fragments the landscape. [At universities with particularly strict interpretations, such as TU Berlin, the country's third-largest technical university, researchers must demonstrate the purely civilian nature of their work, leading to lengthy approval procedures and de facto constraints on research agendas.](#) Moreover, Bundeswehr universities are largely absent from the "[Startup Factories](#)" programs³ designed to strengthen academic spin-offs in key ecosystems, and inspired by the MIT work on [Regional Innovation Engines](#)).

Bavaria's comparatively open approach to cooperation between academia and the Bundeswehr stands in sharp contrast to more restrictive regimes in other federal states, which is why the following passage focuses on TUM as a role model that other universities should follow. TUM benefits from strong state-level political support and a permissive stance toward military research; RWTH Aachen – its closest peer in the Rhineland/ Ruhr region and another of Germany's strongest technical universities – continues to face structural constraints rooted in more restrictive institutional frameworks. In such settings, prime contractors seeking access to academic resources are therefore more likely to approach individual researchers directly and to enter into collaborations that operate largely independently of a university's overall institutional profile.

Against this backdrop, TUM exemplifies what is possible within this landscape. With a growing portfolio of DSR-relevant research and transfer activities, strong industry partnerships, [such as the TUM Security and Defense alliance, outreach to and presence creation in other national emerging DSR ecosystems like Berlin](#) and an increasingly permissive institutional stance toward dual-use innovation, it has emerged as one of Europe's most dynamic nodes for deep tech entrepreneurship – a trajectory that sits uneasily with [predictions that the emergence of a German elite university comparable to those in the United States was improbable](#). What some have begun calling "[Bavaria's MIT](#)" would seem to suggest otherwise. To deepen this momentum in the DSR domain, TUM would probably benefit from a dedicated defense-oriented research and translation infrastructure – analogous to MIT's Lincoln Laboratory – capable of bridging fundamental research, prototyping, and military application within a single institutional framework, a direction the Bavarian state government would probably show willingness to support.

³ Other public funding sources for early-stage entrepreneurship include programs such as [EXIST](#) and [INVEST](#), high-risk SME research funding through [KMU-innovativ](#), and defense-related R&D financed through separate national and European channels, including [major flagship programs such as MGCS](#) and cooperation with research institutes.

The binding constraint for other universities, TUM's practice-oriented development suggests, is less academic potential than institutional design and enabling policy – TUM, uniquely, can build on the activities of UnternehmerTUM and the TUM Venture Labs. [Recent revisions to Bavarian state law](#) illustrate both the scope and the limits of subnational ambition in security-relevant research governance. In July 2024, a new act prohibited civil clauses at state universities and mandated institutional cooperation with the Bundeswehr – signaling an explicit legislative commitment to defense-oriented research. Yet the [Bavarian Constitutional Court's ruling of March 2026](#) introduced a crucial qualification: while upholding the prohibition on civil clauses as constitutionally sound, the Court struck down the mandatory cooperation requirement as incompatible with the rule of law and the constitutionally guaranteed freedom of science.

The ruling is a reminder that defense R&D partnerships cannot be legislated into existence from above; universities are not passive recipients of security policy but constitutionally protected stakeholders whose institutional buy-in is a precondition, not a footnote, of effective military–academic collaboration. The episode is instructive beyond Bavaria. It demonstrates that subnational actors can and should meaningfully reshape and contribute to the parameters of military-academic relations, while simultaneously exposing the constitutional ceilings that constrain such ambitions. At the same time, it accentuates the institutional heterogeneity that characterizes Germany's federal research landscape, as individual states pursue divergent – and unevenly adjudicated – approaches to the governance of DSR-relevant science.

Table 1 presents selected stakeholders from these three regions, broadly aligned with the MIT Innovation Ecosystem Stakeholder Model (Figure 3).

	Greater Munich, Upper Bavaria	Rhineland/ Ruhr Area	Northern Germany
Comparative Advantage/ Stakeholder	Air systems	Land Systems	Maritime Systems
Entrepreneurs/ Start-ups	- Isar Aerospace - Quantum Systems - OroraTech - Helsing - ARX Robotics - Hypersonica	- Code Intelligence - VMRAY - Unchained Robotics - Pixel Photonics - Next Kraftwerke - InCirT	- Subsea Europe Services - PlanBlue - Synergeticon - SeaRoutes - FrameWork Robotics - Polaris
Primes/ Corporations	- Airbus Defense and Space - MBDA - MAN Military Vehicles - Thales DIS CPL - Rohde & Schwarz - Hensoldt	- Rheinmetall - Diehl Defense - Thales Germany - MBDA Germany - KNDS - Rohde & Schwarz - ThyssenKrupp - Leonardo Germany	- Thyssenkrupp Marine Systems - Diehl Defense - Kongsberg Maritime - OHB - Gabler Maschinenbau - Autoflug - Raytheon Anschutz
University/ Research	- TU of Munich - Bundeswehr University Munich - NATO School Oberammergau - Fraunhofer Institute for Applied and Integrated Security (AISEC) - Max Planck Institute for Physics - German Aerospace Center (DLR)	- RWTH Aachen University - Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR - Research Society for Applied Natural Sciences (FGAN) - Technical University of Kaiserslautern - Institute for Peace and Security Policy at the University of Cologne (FiS)	- Kiel University - Institute for Security Policy at Kiel University - GEOMAR Helmholtz Center for Ocean Research - Helmut Schmidt Bundeswehr University Hamburg - Fraunhofer Institute for Silicon Technology (ISIT)
Risk Capital (local)	- Earlybird Venture Capital - Vito Ventures - UnternehmerTUM/ UVC Partners - HV Capital - Munich Venture Partners	- NRW.Bank - High-Tech Gründerfonds (HTGF) - EnjoyVenture - Capnamic Ventures - Tengelmann Ventures	- SHS Ventures - MBG Schleswig-Holstein - Innoport - TecPier - Abacon Capital - GENIUS Venture Capital
Government / Military Facilities	- Military Technical Service Facilities WTD 52 (protection and special technology), WTD 61 (aircraft and aviation equipment) - Various Bundeswehr locations of fighter, air force and air transport units - Innovation Centre of the Armed Forces	- Bundeswehr Service Center Cologne - Procurement Agency of the Ministry of Defense (BAAINBw) - U.S. Ramstein Air Base - Bundeswehr Technical College Cologne - NATO Base Geilenkirchen - Military Technical Service Facilities WTD 41/ 51 (land systems, engineer and troop technology)	- Naval Arsenal Kiel (MARs) - Naval Arsenal Warnowwerft - Naval Base Commands of the Operational Flotilla 1, 2 (close) - Military Technical Service Facilities WTD 71 (ships, naval weapons, maritime technology and research), WTD 91 (weapons and ammunition)

System 2. Aligning the DSR Industrial Base

Innovation ecosystems and the start-ups that they support have become an important source of economic growth and job creation in advanced economies, and are themselves places where ideas, skilled jobs and growing ventures are highly concentrated. However, to deliver DSR capabilities across the range of relevant sectors - from defense to space and communications, energy and compute - the ability to industrialize and produce at scale is also essential. Indeed, a strong industrial base is today regarded as an important deterrent and one that is most effectively deployed when coupled to emerging new capabilities being designed at pace by agile, ambitious start-ups at the cutting edge of a range of deep tech solutions.

Germany has a particular advantage in building its DSR economy given its strong defense industry, its more traditional industrial base and the widely connected traditional SME base across the nation. Indeed, shifting toward DSR and thus adopting a broader definition of the defense industrial base, would include a wider range of corporations, SMEs and adjacent-sector suppliers, and suggests a larger economic footprint, especially as IDEs reshape both the sector's innovation dynamics and its investment narrative.

Even where production has expanded, the scaling of complex platforms such as the Leopard 2A8 tank remains slow by international standards. As a result, persistent capability gaps remain within the Bundeswehr, particularly in technological modernization and military infrastructure (Dorn et al., 2022). The Kiel Institute estimates that output would need to rise roughly fivefold from 2025 levels to shift the balance vis-à-vis Russia, with delivery delays of three years and more persisting (Burilkov et al., 2025); the industry's order-backlog-to-revenue ratio of roughly 3.7 points to the same capacity strain (McKinsey & Company, 2026). Independent estimates underline that the shortfall is European, not merely German: deterring Russia without US involvement would require roughly €250 billion in additional annual spending and around 300,000 additional troops across Europe (Burilkov & Wolff, 2025).

Germany's traditional defense sector (Table 2) must therefore be amplified. This places several internationally established prime contractors in the spotlight, such as Rheinmetall, KNDS, TKMS, Airbus Defence & Space, MBDA, Hensoldt, and Diehl. Their competitiveness is illustrated by two recent major international procurement decisions. [Rheinmetall secured a contract package with Romania worth roughly €5.7 billion in mid-2026 under the EU's SAFE instrument, representing the largest international order in the company's recent history.](#) Similarly, [TKMS was selected in July 2026 as the preferred bidder for Canada's Canadian Patrol Submarine Project, under which the company is expected to enter negotiations to supply up to twelve submarines as part of a reported deal package with a total long-term value exceeding €60 billion.](#)

At the same time, the termination of the joint fighter-aircraft component of the Future Combat Air System (FCAS) in June 2026, following unresolved industrial disagreements, illustrates the considerable coordination challenges of multinational defense programmes. More broadly, European collaborative programs have historically compounded such frictions through *juste retour* work-sharing arrangements, in which politically allocated production shares can dilute scale and learning economies (Hartley, 2014).

Beyond traditional defense-industrial companies, other actors in the German economy are increasingly moving into DSR. This shift is exemplified by the Schwarz Group – the retail conglomerate headquartered in Heilbronn, southern Germany, and best known for operating Lidl stores – which has built an in-house cybersecurity and information technology services division, Schwarz Digits, drawing on infrastructure originally developed to support its retail and e-commerce operations. This expansion has included the acquisition of Israeli cybersecurity firm XM Cyber in 2021, which reinforced the Group's sovereign cloud offering (namely STACKIT, which was offered to external partners in 2002), as the basis for wider services, e.g. sovereign AI.

Table 2: Defense/ Security (D/S) Economic Profile

Indicator	Value / Description
<u>D/S Sector Employment (2022)</u>	~105,000 direct defense industry jobs ~282,000 indirect security industry jobs
<u>D/S Sector Annual Revenue (2022)</u>	€ 47 billion (~65% defense-; ~35% security industry)
<u>D/S SME Contribution (2022)</u>	At least 39% value share at 49% employment
Major D/S Primes	Rheinmetall, KNDS, TKMS, Airbus Defense & Space, MBDA, Hensoldt, Diehl,
Notable Tech Capabilities	Advanced land systems (e.g. Leopard 2), air defense (IRIS-T), aerospace, sensors, EW, submarines
<u>D/S Exports (2024)</u>	€ 13.2 billion (8.1 bn in export value to Ukraine) Key markets: 86% share in export value to EU, NATO; select Indo-Pacific/ Middle Eastern countries
Import Dependence	Still reliant on non-EU tech/components (e.g. ISR systems, C4ISR, spare parts)
Bundeswehr Readiness & Challenges	Operational gaps: limited deployability, ageing infrastructure, personnel shortages
Noteworthy Strategic Defense Initiatives	European Sky Shield Initiative (ESSI), FCAS (common fighter development discontinued in 2026; system-of-systems cooperation continues), MBT evolution
Civil-Military Synergies	Growing emphasis on dual-use innovation and cyber-resilience across public-private lines

As a result, the Schwarz Group is increasingly providing sovereign cloud, cybersecurity, and other digital services as part of a European technology stack for other corporations, while strengthening the Heilbronn innovation ecosystem – [the first German region to participate in the MIT Regional Entrepreneurship Acceleration Program \(REAP\)](#) – by attracting talent from Munich and Switzerland. The Schwarz Foundation (*Stiftung*) further contributes to the Heilbronn ecosystem through programs supporting start-up entrepreneurs, such as Campus Founders, and initiatives that bring key stakeholders together, including the Innovation Park Artificial Intelligence (IPAI), as well as satellite campuses of TUM and ETH Zurich. The Heilbronn case is illustrative not as an anomaly, but as a reminder that entry into the DSR domain does not follow a single institutional logic: defense incumbents, start-ups, and now large non-defense corporations are each finding distinct pathways into security-relevant innovation, often driven by commercial and geostrategic sovereignty imperatives – such as strengthening European sovereignty in cloud computing and cybersecurity – rather than by an interest in the traditional defense market alone.

This defense-industrial landscape is anchored by a small number of prime and industrial contractors that structure large segments of the growing *national defense value chain*. SMEs play a significant role in component production, innovation, and dual-use applications, yet their role in defense markets is often publicly overlooked relative to their broader prominence as the *backbone of the German Mittelstand economy*. Further down the supply chain, Germany's original equipment manufacturers (OEMs) rely heavily on a broad base of SMEs that occupy important positions as Tier-1, Tier-2, Tier-3, and lower-tier suppliers with “hidden champions” – family-owned, niche world-market leaders characteristic of Germany's export-oriented industrial base (Simon, 2009). Its importance for the defense and security sector is both quantifiable and acute: according to government statistics, the core of Germany's defense and security industry generated annual revenues of approximately €47 billion in 2022, with SMEs accounting for around 39% of the total. Harding and Werner (2026), however, suggest that the contribution of the *Mittelstand* may be substantially larger when the analysis extends beyond direct suppliers to include firms operating in the deeper tiers of the defense supply chain. Under either measure, SMEs constitute critical operational nodes in the downstream supply chain (Handelsblatt Research Institute, 2026). System integrators cannot expand production without functioning downstream supply chains, and any bottleneck in Germany's defense expansion does not lie with the prime contractors themselves. Rather, it lies with specialist component manufacturers, precision tooling firms, and materials-processing companies, each of which requires sufficient working capital to recruit staff, invest in additional capacity, and scale production.

In 2022, the sector supported approximately 105,000 direct defense jobs and a further 282,000 positions in related security domains, underscoring its position as a backbone of Germany's Mittelstand economy. Among Germany's roughly 1,600 'hidden champions', firms active in the DSR sector frequently integrate elements of OEM capabilities and strategic supply functions. Notably, the German base is embedded in a wider European supplier network of some 2,500 companies considered critical to the defense supply chain, still marked by limited cross-border cooperation (Clapp, 2024).

While the industrial base in Germany is strong, the environment of conservatism coupled with a slowly shifting reluctance to engage with DSR constitutes a structural limitation for new entrepreneurial entrants. Unlocking the innovation potential of start-ups within the DSR sector requires dense and open interaction between new market participants and the wider industrial base. Indeed, the 2025 German Startup Monitor reports that collaboration between start-ups and established firms, including SMEs, has declined to its lowest level in five years despite an improvement in perception of defense and security-related activity. The pattern is consistent with long-standing evidence that the Mittelstand's ownership and financing model is, in important respects, indeed very different from venture-style entrepreneurship (Pahnke & Welter, 2019). Added to this, the defense sector exhibits high internal innovation intensity – with R&D expenditure accounting for 7.1% of turnover and a substantial share of employees working in R&D (12%) – this model of vertical integration limits the absorptive capacity for external innovation. Opportunities to integrate complementary, start-up-driven technologies into existing systems therefore remain underutilized, weakening system-level adaptability.

Gaps arise in part because the relationship between IDEs and the large industrial base remains unsystematic and dependent on individual initiatives. Venture data illustrate the point: since 2020, Hensoldt and Rheinmetall have each participated in only two VC rounds of European defense start-ups, compared with six for France's Safran. Where large system integrators rely primarily on in-house R&D or subsidiaries and make limited use of open innovation models, start-up participation is often confined to the component level, with limited access to system-critical development processes or opportunities for long-term integration into platform architectures. This hierarchical value-chain structure contrasts with civilian high-tech sectors, where incumbents more actively engage start-ups as innovation partners.

To date, geographic proximity has done little to offset these institutional frictions. DSR start-ups face parallel challenges: while many large defense companies engage in international R&D partnerships, domestic collaboration is frequently limited by regulatory uncertainty and compliance concerns. As a result, the potential benefits of clustering – shared talent pools, joint infrastructure, or early-stage testing facilities – remain largely unrealized.

System 3. Aligning DSR Finance and Expanding the Capital Stack

Germany's DSR-financing landscape has shifted more in the past three years than in the preceding three decades. At the level of the national government, the constitutional exemption of DSR expenditure from the debt brake, plus the partial opening of KfW instruments to defense firms, including through the [launch of the Deutschlandfonds](#), and the recent announcement of a new [public equity investment vehicle for DSR start-ups](#) collectively represent a significant reconfiguration of public financing that few other European economies have pursued at comparable speed.

Defense primes benefit from long-term procurement contracts from the state and can then access institutional capital – such as syndicated loans, pension funds, asset managers, and public equity. Public markets have repriced the sector accordingly: [an aggregate index of European defense equities gained some 168% between February 2022 and mid-2025 relative to the broader market](#). Germany's capital market structure, however, remains only partially aligned with the financing requirements of DSR SMEs and start-ups who typically lack the revenue stability and creditworthiness needed to access comparable instruments (Bussenius & Schiewe, 2023).

In Germany (and across Europe), [access to finance remains a major concern for 44% of defense SMEs](#). For example, while the OECD scoreboard puts the average interest rate for German SMEs at 5.3% for 2024, SMEs in defense supply chains frequently face 8% or more depending on collateral – with some, start-ups in particular, finding no debt access at all. For SMEs, as well as for IDEs, access to working capital is crucial. However, traditional working capital lenders, notably commercial banks, tend to avoid defense-linked ventures due to opportunity costs, compliance considerations and long, uncertain development cycles. As a result, funding limits constrain both early development and subsequent scale-up. The same is true, to a lesser extent, for the larger Primes whose cost of capital is generally higher than their civilian counterparts. At the root of these financing gaps lies a complex interaction of regulatory exclusions, continental European industry's over-reliance on bank debt, compliance-driven investment constraints, and long-standing weaknesses in Germany's defense financing stack.

Collateral should, in principle, offer a way out (Bester, 1985). Falckenberg (2026) shows why this mechanism is structurally weak in the defense context, identifying four layers of collateral that are administratively devalued or unusable: end products and key components subject to export-control approval before any third-market sale; dual-use machinery restricted by the EU dual-use regulation; inventories so platform-specific that they cannot be redeployed; and receivables against the procurement office that are credit-safe but decoupled from cash flow by the separation of order and call-off. Where collateral cannot do its screening work, guarantee-based risk-sharing must substitute but this is something Germany's financing architecture lacks at scale.

- [KfW's general corporate instruments – such as the Climate Action Offensive for Companies \(Program 293\), the KfW Syndicated Loan for Sustainable Transformation \(Program 291\), and environmental protection programs \(240, 241\) – have been opened to DSR firms since 2025](#), guarantee schemes are not specifically aligned with the long-term and high-risk profile of defense applications, with liability releases typically capped at 50% and lending constrained by EU state-aid rules.
- Standard program ceilings for SMEs (typically around €25 million) are often too low for capacity expansion at DSR scale, and the one scheme with a 90% liability release (UBR-222) is confined to liquidity protection against Ukraine-war turnover losses rather than long-term capacity investment.

Extended commercialization cycles and uncertainty in public procurement create persistent cash-flow pressures for both SMEs and start-ups with research-intensive, capital-heavy business models. Conventional VC annual return expectations are often difficult to reconcile with these dynamics (Schneider, 2024), particularly under conditions of shifting political priorities and opaque capability planning within the Bundeswehr.

Commercial banks amplify these challenges by classifying defense firms as high-risk borrowers due to export controls, compliance obligations, and concentrated exposure to a small number of procurement programs. The incremental implementation of Basel III reforms (“Basel 3.1”, widely referred to in industry usage as “Basel IV”) increases regulatory capital requirements through output floors and higher risk charges, raising the cost of lending to the sector and constraining banks’ willingness to engage – sometimes described as a pursuit of the ‘stability of the graveyard,’ where excessive prudence suppresses credit and economic dynamism.

Under the Basel 3.1 output floor banks using internal models must hold capital of at least 72.5% of the standardized-approach requirement. Moody’s identifies Germany, with its large population of unrated, *Hausbank*-dependent Mittelstand borrowers, as among the most affected jurisdictions in Europe (Moody’s, 2026; Harding & Werner, 2026). The effects coincide with an overall weak SME lending dynamic: in the second quarter of 2026, 40.5% of German SMEs engaged in credit negotiations reported restrictive bank lending behavior while the share of SMEs entering loan negotiations at all has fallen to 19.3% (Körner, 2026).

The consequences of these financing gaps are not merely fiscal. They are operational. Structural undercapitalization in Germany’s defense supply chain, particularly among Tier-2 to Tier-4 SME suppliers, translates directly into constrained production capacity and escalating costs. Under conditions of synchronized allied rearmament, this capacity constraint generates precisely the scarcity pricing dynamics that Harding (2026) identifies as a defining feature of the current security environment: where supply cannot scale to meet demand, prices become discontinuous rather than incremental, and nominal budget increases are further eroded beyond what aggregate inflation figures suggest. This capacity gap is being actively worsened by the underfinancing of its innovation ecosystems and its industrial base.

Turning to the wider DSR innovation ecosystem, beyond SMEs, the German defense supply chain continues to accelerate, driven by rising procurement volumes. Meeting these financing needs requires a broader capital stack that extends beyond traditional bank lending. An important component is VC, particularly for IDEs as ambitious, growth-oriented start-ups, where investment responds positively to a clear “line of sight” to future contracts:

- Supported by the federal government's clear commitment to defense spending, VC investment in German defense start-ups has risen nearly tenfold in less than four years according to Dealroom (10/7/2026): [from US\\$362 million in 2023 to US\\$552 million in 2024, US\\$1.2 billion in 2025 and US\\$3.6 billion in 2026 to date, more than in 2020-2025 combined](#).

More broadly, outside the DSR sector that public demand helped spark, Germany's venture market remains small by G7 standards.

- In 2025, VC investment in Germany amounted to US\$8.2 billion – about US\$98 per capita and 0.16% of GDP – placing Germany fifth among the G7, behind the United States (US\$819 per capita; 0.91% of GDP), the United Kingdom (US\$390; 0.68%), Canada (US\$166; 0.30%), and France (US\$116; 0.24%), and ahead only of Japan and Italy.
- Although Germany generates almost 10% of G7 GDP, it attracts less than 3% of G7 venture capital – and the gap is not closing: between 2023 and 2025, German VC investment grew by just 4%, against 43% in the United Kingdom and 86% in the United States (Dealroom.co, 2026; World Bank, 2026).

Excluding defense, German VC has hovered between US\$7.0 billion and US\$7.7 billion a year since 2023. The market's recent growth is therefore attributable entirely to defense start-ups, whose share of German VC rose from under 5% in 2023 to almost 15% in 2025 and roughly one-third in 2026 to date (Dealroom.co, 2026). This underscores how thin the VC foundation remains despite recent momentum. The resulting Series A bottleneck has repeatedly led German defense start-ups to relocate to jurisdictions such as France, the United Kingdom, or the United States, where tax treatment, public co-investment schemes, and access to scale-up capital are more favorable.

Early-stage DSR capital formation has also been particularly constrained by restrictive compliance rules, environmental, social, and governance (ESG) and sustainability criteria, reputational concerns, and supervisory barriers that have led many investors to exclude defense-related activities altogether. [ESG-related or simply reputational risks discourage institutional investors, banks, and pension funds from engaging with DSR projects.](#) While the concept of “sustainable security” has gained visibility since 2022, regulatory and market adaptation has proceeded only slowly (Schneider, 2024).

Defense-related activities therefore remain within categories most frequently excluded by sustainability screens, and even funds classified under Article 8 or Article 9 of the EU Sustainable Finance Disclosure Regulation (SFDR) continue to underweight the sector despite the absence of formal prohibitions.

- The [European Commission’s study of defense SME financing](#) reaches a similar conclusion: the binding constraint stems less from formal regulation than from investors’ internal ESG and reputational policies. Indeed, many of these barriers have since been addressed. [Germany’s December 2024 security and defense industry strategy](#) clarified that existing regulation does not restrict investment in the sector, including by sustainable funds (BMF, 2025).
- At the EU level, a [November 2025 Commission Notice and Delegated Regulation](#) narrowed the definition of “prohibited weapons” to controversial categories, thereby ending the sector’s automatic exclusion at the benchmark and fund level from mid-2026.
- Supervisory dynamics, however, continue to pull in the opposite direction. The European Central Bank has embedded climate and nature-related risks in its 2026–2028 supervisory priorities and, in late 2025, imposed its first periodic penalty payment on a major euro-area bank for deficiencies in climate-risk management, with the Bank of England pursuing a similar supervisory direction (ECB, 2025; Bank of England, 2025).
- Banks may therefore retain strong incentives to maintain ESG-based risk models in which defense exposure remains flagged, notwithstanding the sector-specific regulatory clarifications (Falckenberg, 2026).

These dynamics generate structural financing gaps for DSR ventures, many of which rely on capital-intensive R&D. Start-ups often respond by structurally separating defense-related intellectual property to preserve access to sustainability-labeled capital. Such strategies fragment organizational structures, impede scaling, and weaken knowledge transfer between civilian and military applications, undermining the very logic of ‘dual-use’ innovation (whereby both the defense and civilian/commercial sectors benefit). Uncertainty regarding ESG classification further raises risk premia and constrains access to growth capital.

Public support programs have expanded, but their eligibility criteria often favor established firms, undermining stated policy objectives of fostering innovation and entry. The case of KfW⁴ illustrates this tension: while the bank has participated in syndicated lending for large defense contractors (Bussenius & Schiewe, 2023), [both KfW and its subsidiary KfW Capital excluded direct investments in arms and munitions companies until the rules were revised in April 2025.](#)

Unlike France or the United Kingdom which have established hybrid financing vehicles dedicated to defense innovation, Germany has historically excluded defense either explicitly or indirectly through loosely defined dual-use criteria. [Because dual-use reflects an entrepreneurial strategy rather than a clearly bounded technology category,](#) this approach has produced asymmetric financing conditions across DSR domains. Security-relevant technologies such as sensors, AI, or advanced materials have often been eligible for public funding only if military applications were downplayed or organizationally separated, generating governance frictions and inefficiencies. For start-ups, this constellation produces a pronounced financing gap in the ‘valley of death’ between research and market entry.

⁴ A further, and unusual, [tension arises from plans to transfer €500 million of KfW profits to the federal budget in each of 2027 and 2028.](#) Such profit extraction would represent a departure from KfW’s traditional model of retaining earnings to support its promotional mandate, even as the institution is being asked to mobilize greater private investment.

The *Deutschlandfonds* is designed to address some of these financing constraints:

- Launched in 2025, it explicitly includes start-ups and scale-ups in DSR domains, signaling that Germany is beginning to align its financing architecture with critical industries (Skipper, 2026). [Its structure combines roughly €1 billion in budget funds, €30 billion in federal guarantees, and €5.3 billion from KfW, with the aim of mobilizing up to €130 billion in private investment.](#) A €3.3 billion venture pillar through 2030 earmarks around €2 billion for deep tech, biotech, and the security and defense industry, while Scale-up Direct provides co-investments of up to €50 million per company (BMWE, 2025; Goschin, 2026). Yet its early record also highlights the distance still to travel: by mid-2026, the only publicly disclosed defense-related transaction was a Scale-up Direct co-investment in Quantum Systems alongside HV Capital.
- Questions remain about how much additional risk capital the fund will mobilize and what share will ultimately reach defense innovation, and how far it will spread beyond the already successful unicorns in the sector. The same applies to the government's [new start-up and scale-up strategy](#), which recently announced the creation of a public equity investment vehicle specifically targeting DSR start-ups. As a sovereign commitment, however, it represents a meaningful step toward the blended, mission-oriented financing stack that DSR innovation requires.

Beyond national funding opportunities, firms can turn to foreign investors to bridge financing gaps. German DSR start-ups can increasingly tap into a growing European VC market, [with European defense-tech VC funding rising from US\\$611 million in 2021 to US\\$2.6 billion in 2025 and a record US\\$7.4 billion in the first nine months of 2026 alone – now 11.1% of all European VC, up from 0.5-1% until 2020](#), according to Dealroom & Resilience Media (2026). As capital requirements increase, particularly at later stages or for capital-intensive deep-tech ventures, US investors can become an important source of financing. Typical ticket sizes among German venture funds – [often in the range of US\\$1–10 million](#) – remain insufficient for many capital-intensive defense technologies. International investors, particularly from the United States and Scandinavia, have therefore played an important role in financing German defense innovation.

Transactions such as General Catalyst's acquisition of the German VC fund La Famiglia and its joint investment with Saab in Helsing (seeded by the Swedish entrepreneur behind Spotify) exemplify this dynamic. [While foreign capital inflows can be interpreted as a vote of confidence in Germany's innovation base, structural dependence on external investors in DSR domains raises concerns about technological sovereignty, security policy autonomy, and entrepreneurial relocation.](#) Empirical evidence suggests that approximately one in ten European start-ups backed by US VC relocates abroad over time, especially to the US (Weik et al., 2024), a pattern that if applied to the German defense sector will contribute to the outflow of talent, intellectual property, and institutional knowledge much needed for the DSR innovation economy.

- High-profile cases such as Helsing demonstrate the scalability of German defense deep tech and, at the same time, the reliance on funding beyond Germany and even Europe. Its latest US\$1.8 billion Series E (completed in July 2026 at a valuation of US\$18 billion – the largest financing round for a defense start-up in European history) drew new and existing investors including Dragoneer Investment Group, Lightspeed Venture Partners, Growth Equity at Goldman Sachs Alternatives, JPMorganChase and Canada's CPP Investments.
- That said, the prior €600 million Series D in June 2025 was led by Daniel Ek's Prima Materia (Sweden), as prior rounds were dominated by European investors (including Swedish defense group Saab), as the German start-up could not get its early-stage capital in Germany. As a result, Helsing remains majority European-owned, with the company's capital structure shared to keep the Munich-based company in European hands, especially as a company focused on becoming a "sovereign" alternative for European countries.

Cross-system Solutions

A range of potential solutions to address some of the most persistent challenges is apparent:

System 1. Innovation Ecosystems

- **Harmonize the governance of security-relevant research across the federal landscape.** With civil clauses institutionalized at more than seventy institutions and starkly divergent state practices, the single highest-leverage reform is a federal–state pact on defense-related research: incentives rather than mandates – the clear lesson of the Bavarian Constitutional Court’s 2026 ruling. At its core, the BMFTR should establish a dedicated DSR funding line that provides universities and research institutions with strong financial incentives to expand defense- and dual-use research, complemented by model cooperation agreements that safeguard academic freedom and the opening of flagship transfer programs such as the Startup Factories to Bundeswehr universities. The particularly high returns to R&D investment provide a strong economic rationale for treating such funding as part of the defense exemption from the debt brake, allowing strategically important DSR research expenditure, where necessary, to be debt-financed rather than crowded out by competing demands on the regular federal budget.
- **Match ecosystem instruments to each region’s stage of development.** A key lesson from innovation-ecosystem research is that regional strategies for accelerating innovation need to be tailored to the specific needs, capabilities and maturity of each regional ecosystem rather than applied uniformly across regions. Germany’s regional record reinforces this finding, revealing a clear maturity gradient – Greater Munich at investment and system integration, the Rhineland-Ruhr area at incubation and industrial localization, and the north at external scouting and institution-building – and policy should follow that gradient rather than average across it. In Munich, deepen what demonstrably works: prime–start-up equity partnerships and structured program access on the Hensoldt–Quantum Systems model. In North Rhine-Westphalia, fund the incubator-to-production bridge so that regional start-ups reach certified manufacturing. In the north, prioritize institution-building of the kind the planned Kiel innovation center represents, tasked explicitly with converting locally anchored naval demand into local start-up participation. Replicating the Erding innovation-center interface, which gives civilian innovators structured access to testing, procurement expertise and secure infrastructure, across the other clusters would give every region its own procurement doorway.
- **Remove the frictions that keep the clusters from compounding into a national system.** Entrepreneurial location decisions are often not driven by technological complementarities; a coordinated Länder approach to DSR cluster policy, orchestrated through the new National Security Council for example, would dampen that dynamic. Shared, cross-regional test and sandbox infrastructure would let a start-up in Kiel or Essen validate prototypes under near-operational conditions without needing proximity to Munich, thereby addressing the scarcity of sandbox facilities documented below. Regional economic-development agencies, in turn, should conduct rigorous assessments of their own innovation ecosystems to identify missing interfaces between entrepreneurs, primes, investors, research institutions and military users, rather than relying on isolated and non-comparable snapshots.

System 2. DSR Industrial Base.

- **Make openness to new entrants a design requirement of major programs rather than a courtesy.** Vertical integration and limited absorptive capacity confine start-ups to component-level roles, and corporate–start-up collaboration has fallen to a five-year low; flagship programs should therefore be architected from the outset with modular structures, open interfaces and credible subcontracting plans that give IDEs access to system-critical development. Structured entry paths of the kind Hensoldt’s FCAS Accelerator and the Hensoldt–Quantum Systems partnership have demonstrated can be institutionalized across the primes, including venture-client and accelerator units with real contracting authority, so that

integration into platform architectures no longer depends on individual corporate initiative. Venture studios (Coelsch-Foisner et al., 2026) offer a further promising model for defense companies: by systematically developing and validating ideas independently of pre-existing founding teams, they can translate identified capability needs into viable ventures and expand the pipeline of technologies available for integration into major programs.

- **Cut the fixed costs that certification and intellectual-property regimes impose on smaller firms.** Security-related certification is calibrated to the compliance capacity of large firms; proportionate, milestone-based certification tracks for SMEs and IDEs, mutual recognition of test results across the Bundeswehr's technical centers (WTDs), and standardized collaboration templates that let start-ups retain core intellectual property when working with larger partners would lower entry barriers without diluting security standards. Because these fixed costs fall hardest on precisely the firms that carry much of the sector's technological dynamism, such administrative reforms are among the cheapest capability investments available to the state.
- **Treat Tier-2 to Tier-4 supplier development as an industrial-policy task in its own right.** Record order backlogs will convert into output rather than scarcity pricing only if the specialist component makers, precision-tooling firms and materials processors can recruit, invest and qualify at pace. A structured supplier-development program – second-sourcing targets in major contracts, qualification support for manufacturers entering from civilian sectors, and systematic use of the BwPBBG's market-consultation and pre-payment instruments – would widen the industrial base while reducing single-source risk, and would direct part of the coming spending wave deliberately at the level of the value chain where both the capacity constraint and the employment effects are concentrated.

System 3. DSR Finance/Capital Stack

- **Use the fiscal-signal window opened by the 2025 debt-brake reform deliberately, rather than let it lapse by default.** Financing defense adequately through debt has correctly signaled to market actors and the innovation ecosystem that state demand is durable, but the Bundesbank has indicated that stricter fiscal discipline will need to be restored within the next decade. The decade-long commitment this creates should be converted into instruments that outlast the political cycle in which they were made – multi-year budget lines for the Deutschlandfonds and the equity vehicle discussed below, framework agreements with primes and suppliers, procurement pipelines that extend past a single legislative term – rather than one-off appropriations. Absent that conversion, ecosystem and finance instruments calibrated to today's fiscal generosity risk a hard landing once discipline reasserts itself, precisely as regional DSR ecosystems are still scaling.
- **Extend guarantees and risk-sharing deep into the supply chain, where national instruments alone cannot systematically reach.** Even though Germany has shown a strong sovereign commitment to DSR, most visibly through the politically difficult decision to reform the debt brake, EU state-aid rules and Basel 3.1 risk-weight requirements constrain how far German guarantees, liquidity and risk-sharing can extend to the SMEs and growth-stage suppliers. Several multilateral financing initiatives are currently underway, including the EU's Security Action for Europe (SAFE) instrument and the UK's proposed Multilateral Defence Mechanism (MDM), which focuses on joint procurement. The multilateral Defence, Security and Resilience Bank (DSR Bank) may be well suited to Germany's needs: Given Germany's AAA sovereign credit rating and its resulting access to favourable borrowing conditions, the Bank's added value would lie not so much in sovereign lending than in the guarantees and risk-weight substitution it could offer firms in the defence, security and resilience (DSR) sector. The range of multi-lateral approaches could complement the lending and guarantee facilities provided by KfW while reducing KfW's exposure in the DSR sector.
- **Target the Deutschlandfonds specifically at the DSR economy rather than leaving its relevance implicit.** Four refinements would do this: (i) create an explicit DSR allocation, or at minimum a reporting line, within its Scale-up Direct and guarantee windows, so the defense

share of deployments becomes measurable; (ii) direct part of its roughly €30 billion guarantee capacity to backstop working-capital lending to defense SMEs, where standard KfW liability releases capped at 50% leave substantial risk on commercial banks' balance sheets; (iii) have KfW Capital increase its commitments to specialized defense and dual-use venture funds, building on its April 2025 removal of the arms-investment exclusion; and (iv) ensure close coordination between KfW Capital and the new dedicated equity vehicle announced in the government's July 2026 start-up and scale-up strategy, so that the two instruments complement each other and finance not only established scale-ups but, in particular, early-stage DSR start-ups. At the same time, equity remains an expensive form of capital for most founders and SMEs, so public equity participation should be deployed selectively and designed to complement, rather than crowd out, less dilutive forms of financing.

Shaping Demand: Military Strategy & Demand Signals

The government plays a key role as a market-maker in DSR. Any nation seeking a strong DSR economy must generate credible demand for solutions through government procurement or adjacent commercial markets. Moreover, this demand must be backed by credible commitment: no entrepreneur or investor will allocate scarce resources to DSR capabilities if the market is not there. DSR innovation cannot be driven by patriotism alone, as defense investments are highly asset-specific – including in physical capital, location, and security-cleared human capital – exposing suppliers to hold-up risks once contracts are signed (Williamson, 1979). Where procurement decisions and actual call-off orders are separated and budgets remain politically volatile, holding back ex ante capacity investment is therefore not a market failure but a rational response – one that only credible, multi-year purchase commitments can overcome.

According to the Kiel Procurement Tracker (Burilkov et al., 2025), German procurement volumes increased markedly between 2022 and 2024, reaching a cumulative total of approximately €170.5 billion since 2020. However, long delivery timelines, driven by Europe-wide order increases, combined with the transfer of existing systems to Ukraine have together delayed the visible expansion of military capabilities. The broader procurement record reinforces this assessment: processes have only marginally accelerated since February 2022 (Wolff et al., 2024). Germany has recently sought to remedy this by providing clearer market signals through its [security and defense industrial strategy](#).

Persistent obstacles, however, include rigid civil–military separation, limited adoption of digital and autonomous systems, risk-averse investment practices, and insufficient NATO and EU coordination. Similar concerns are echoed in [Germany's 2025 space security strategy](#), which emphasizes interoperability and greater risk tolerance in innovation. Both documents also identify several priority capabilities – including AI and data processing, surveillance and sensors, military IT, naval systems, satellite and launch technologies, and cybersecurity – in which IDEs from Germany's innovation ecosystems are likely to play a key role. Together, these strategies strengthen the priority-setting and signaling stage of the demand chain for start-ups and scale-ups seeking to access Germany's rising DSR spending.

Moving from general demand signals to specific requirements and experimentation, the Bundeswehr's Cyber Innovation Hub, established in 2017, aims to improve links between cyber start-ups, intra-institutional innovation capacity and the military end-user. Alongside the Cyber Agency, founded in 2020, and the Bundeswehr Innovation Center in 2026, it signals expanding institutional commitment to disruptive and defense-oriented innovation. Since its establishment, the Hub has launched more than 180 innovation projects, of which around 40 have been adopted by the Bundeswehr. This conversion gap illustrates a central demand-side challenge: Germany has become increasingly effective at signaling and testing demand, but can still improve at converting successful experimentation into scalable procurement.

A key component of this conversion process is a set of [dedicated innovation sandboxes and regulatory experimentation environments for defense and dual-use technologies](#). Unlike France, the Netherlands, or the United Kingdom, Germany offers few settings in which security-relevant technologies can be tested under realistic conditions with regulatory support. Although the [European Commission emphasizes the importance of testbeds in its defense omnibus package](#) and the Federal Ministry for Economic Affairs (BMWE) maintains a general ['real-world labs'](#) framework, dedicated defense or dual-use sandboxes remain rare. As a result, start-ups, SMEs, and research institutions have limited opportunities to validate prototypes under near-operational conditions without facing long administrative processes to use Bundeswehr infrastructure or incurring delays by being forced to test in other countries. The absence of such environments confirms high asset-specificity and consequently technological and regulatory uncertainty.

For government customers and investors, the lack of realistic testing and validation environments raises perceived risk, making it more difficult to assess technological maturity and market readiness. This opacity reinforces cautious investment behavior and constrains capital inflows into the defense sector. In the absence of empirical test data, regulatory frameworks tend to rely on abstract risk assessments rather than practice-based evidence. This increases the likelihood of

misaligned or overly restrictive rules, and contributes to a predominantly reactive regulatory approach that responds to innovation *ex post* rather than accompanying it. The resulting institutional configuration limits the state's capacity to reconcile innovation promotion with security, compliance, and societal safeguards and further weakens the link from testing to procurement across Germany's DSR innovation ecosystem.

Germany has increasingly recognized this gap and, since 2022, has introduced a series of reforms aimed at shortening the path from market signaling and experimentation to procurement, offering lessons that may prove instructive for other countries.

- The new planning and procurement acceleration law (*Gesetz zur beschleunigten Planung und Beschaffung für die Bundeswehr*, BwPBBG), in force since February 14, 2026, simplifies procedures for small-quantity procurements, introduces partial prepayments that alleviate liquidity pressures for start-ups and SMEs, expands the scope for market consultations and innovation-friendly procedures from which start-ups in particular stand to benefit, and prioritizes interoperability with allies. Recent procurement decisions point to positive developments: by procuring loitering munitions from three different suppliers – the start-ups STARK and Helsing, alongside Rheinmetall – the German government has demonstrated a growing willingness to engage with IDEs.
- Recent changes have also eased procurement constraints that had limited the Cyber Innovation Hub's ability to scale successful projects, including restrictive direct-award thresholds and EU-wide tender requirements. At the same time, the Hub's budget has been substantially expanded: the 2026 federal budget allocates €40 million to the Cyber Innovation Hub, up from approximately €10 million previously.
- A reform of the decades-old procurement price law (*Preisrecht*) is currently being prepared within the BAAINBw, [with particular attention to the Bonner Formel](#), which determines permissible profit margins for contracts without established market prices. By linking returns partly to firms' own value added and capital intensity, the formula favors traditional asset-heavy production and can disadvantage software- and AI-driven start-ups, whose value creation rests more heavily on intellectual property and human capital. Adjusting the formula could therefore better remunerate digital innovation and improve start-ups' ability to scale, with reform proposals expected by the end of 2026.
- With the start-up and scale-up strategy, the federal government has for the first time systematically integrated security and defense firms into national start-up policy, including dedicated equity instruments and a mandate to examine opening the Federal Agency for Disruptive Innovation (SPRIND) funding to defense-relevant projects.

That faster procurement is possible within the existing system is illustrated by the Defense Ministry's Special Staff Ukraine (Sonderstab Ukraine): [with fewer than 20 staff, it can move from an identified requirement to a signed contract in about two weeks](#), because Ukraine concludes the contracts while Germany finances them and reviews prices and terms. Yet progress in formal rules has not fully translated into a consistently open and efficient procurement environment. Entrenched practices continue to impose costs on both the state and new entrants, as a series of procurement cases illustrates:

- As early as 2022, [the Federal Court of Audit criticized the budgeting of core special fund programs – including the F-35 and the heavy transport helicopter – in collective budget titles that allow funds to be shifted between projects, weakening the credibility of commitments](#); in 2023, it also criticized the Bundeswehr for purchasing standard batteries from a system provider at approximately fifteen times the market price without issuing a separate tender or considering alternative suppliers. This case illustrates procurement inefficiency and weak price discipline, while market-entry barriers are illustrated by [the replacement of the occasionally controversial G36 assault rifle. The tender issued in April 2017 for 120.000 rifles \(5.56mm or 7.62mm caliber\), valued at approximately €245 million excluding VAT, contained highly specific technical requirements. Tender applicant SIG Sauer argued that these specifications favored](#)

[the incumbent supplier Heckler & Koch and withdrew from the process in the same year. What followed were multiple testing rounds and additional requirements, as the initially preferred solution failed to meet all criteria. Although the contract was awarded in 2020 to C.G. Haenel \(MK556\), a complaint by Heckler & Koch led to the annulment of the award. Further reviews, delays, and litigation ensued, and only at the end of 2022 – after final parliamentary approval – was procurement of C.G. Haenel's HK416 A8 authorized](#) (over the incumbent's objections).

- Similarly, the planned replacement of the Fuchs armored personnel carrier, despite its long service history and production across more than 30 variants by German SMEs, illustrates the difficulty of introducing alternative suppliers within established industrial networks. [Germany's accession to the European CAVS program in 2023 and the decision to procure the Finnish Patria 6×6 prompted resistance from domestic industry, leading to discussions on licensed production to preserve local value creation.](#) While such arrangements may mitigate industrial disruption, they also illustrate how concentrated public demand, incumbent-oriented requirements, switching costs, and domestic industrial-policy considerations can reinforce established supplier structures and constrain market entry. Tender design and performance requirements are frequently aligned with incumbent capabilities, limiting opportunities for SMEs and IDEs and weakening the state's bargaining position over time. [The first serial contract for 296 Patria 6×6 vehicles was approved in December 2025.](#)

The consequences of weak demand coordination extend beyond procurement efficiency: when fiscal demand rises faster than the industrial base can respond, additional spending can translate into prices rather than capability. Defense markets are typically organized as monopsonies, with the state acting as the dominant buyer. Combined with high sunk costs and significant economies of scale, historically limited national demand can result in structurally higher unit costs than in more integrated markets (Dunne, 1995). These structural characteristics become particularly consequential when demand rises rapidly. When relatively price-inelastic government demand confronts similarly inelastic short-run supply – reflecting limited capacity, long lead times, and specialized inputs – increases in defense spending can translate disproportionately into higher prices rather than additional output.

This dynamic is reflected in ammunition price increases of 300-600% since 2021 and scarcity pricing in specialized components exceeding 1,000% in some cases (Harding, 2026). Between these poles, intermediate categories such as missile and air-defense systems (+20–50%) and semiconductor inputs (+10–25%) have repriced as well (Harding, 2026). The 2025/26 Iran conflicts illustrated how quickly allied inventories can approach exhaustion under such conditions: within weeks, US stocks of key interceptors were drawn down to critical levels and more than 1,000 of roughly 3,100 available Tomahawk cruise missiles expended (Cancian & Park, 2026) – demand conditions under which European production capacity, too, becomes a binding constraint.

The procurement cases and pricing dynamics point to a common set of structural constraints. Rigid procurement practices, the Bundeswehr's position as dominant buyer, asymmetric risk allocation along the value chain, and demanding certification and intellectual property regimes can collectively disadvantage new market entrants, weaken competitive dynamics, and dampen innovation incentives. The resulting administrative and compliance costs fall disproportionately on smaller firms and start-ups.

A number of issues therefore remain unresolved, although policy proposals increasingly recognize them:

- Procurement rigidity continues to drive efficiency losses for the state. Centralized decision-making, particularly within the Bundeswehr's procurement office BAAlNBw, slows the process from requirements definition to acceptance and limits rapid innovation cycles.
- Long and binary decision structures, often culminating in winner-takes-all outcomes, reduce competitive pressure and can increase costs – the classic incentive problems of defense

contracting, in which cost-plus terms invite padding, fixed-price terms shift risk onto the supplier, and every stage of a multi-tier process extracts information rents (Rogerson, 1995).

- Certification and intellectual property regimes impose constraints on market entry. Security-related certification processes are calibrated to the capacities of large firms able to sustain prolonged compliance efforts, while IP arrangements that require firms to cede or share IP rights in collaborations with larger partners can further constrain participation.
- [Proposals by the Federal Ministry for Economic Affairs and Energy to allocate a growing share of procurement budgets to innovation-driven projects signal awareness of the problem](#), but they remain largely declaratory in the absence of binding institutional reforms and dedicated funding instruments. The advisory-board paper underlying these proposals is notably more specific – a technology quota rising from 10% of the procurement budget in 2026 to 30% by 2030, a ten-year defense investment plan, and standing “financing forum” for the sector (Lange et al, 2025).
- [Demand-signal stability remains fragile: draft budget figures for 2027 trim munitions outlays to €9.6 billion from €11 billion in 2026](#), and parliamentary approvals increasingly carry conditions – [as when the Budget Committee tied its July 2026 release of funding for four MEKO A-200 frigates to cost-transparency requirements, quarterly reporting and consideration of suppliers affected by the canceled F126 program](#). The pattern is confirmed comparatively: Germany’s 2025 procurement volume of roughly €85 billion was Europe’s largest – against some €25 billion in the United Kingdom and €21 billion in Poland – yet the German mix shows the slowest shift toward new-paradigm systems, and a growing share of orders is issued without specified delivery dates, an anomaly absent in both comparators (Wolff et al., 2026). Such conditions are legitimate instruments of parliamentary control, but the resulting volatility complicates the long-horizon capacity investments that suppliers – and their financiers – must underwrite.
- The remedy is clear: multi-year, volume-committed offtake guarantees and framework contracts with firm call-off schedules would convert fiscal signals into bankable demand, addressing at source the hold-up risk that keeps suppliers’ ex ante capital demand below requirement (Falckenberg, 2026). This distinction matters because framework agreements do not necessarily constitute firm purchase commitments: planned quantities may remain non-binding until individual BAANBW call-offs create actual obligations, limiting the extent to which suppliers and financiers can treat headline volumes as bankable demand.

Taken together, Germany’s remaining demand-side challenge is therefore less the absence of political commitment, strategic priorities, or aggregate procurement spending than the conversion of these signals into predictable and bankable orders. In the terms of the framework developed here, the unfinished task is to shorten and stabilize the chain from priority-setting and signaling through testing to the order that ultimately activates the DSR base.

Shaping Government Coordination & Institutional Culture

The German DSR economy displays a clear pattern: It possesses many of the individual components of a strong DSR economy, but the connections among them remain uneven. Its innovation ecosystems generate new technologies, the industrial base is expanding to provide substantial production capacity, capital markets are increasingly willing to finance DSR firms, and government demand has become both larger and more explicit. Yet these elements are still too often governed through separate institutional channels and remain poorly aligned. Coordination is therefore not an additional building block of the DSR economy, but the cross-cutting mechanism through which political priorities, research, capital, industrial capacity, and procurement are aligned around common missions.

Coordination

Building a DSR economy that is fit for purpose and capable of serving as a credible deterrent requires coordinated policy across governance levels and institutional boundaries. The state must

do more than fund individual programs: it must connect the actors that generate technologies, finance their development, industrialize them, and ultimately procure and use them. Germany has taken meaningful steps in this direction. The creation of a [National Security Council](#)⁵, the denomination of the Federal Ministry of Education and Research as the Federal Ministry of Research, Technology and Space (BMFTR), and the growing interministerial recognition of innovation-driven DSR as a strategic priority all signal genuine institutional movement.

The central problem is not a lack of innovation funding resources. Germany spent [approximately €130 billion on R&D in 2023, equivalent to 3.1% of GDP](#), and possesses an extensive network of universities, Fraunhofer institutes, Max Planck institutes, the DLR, and other research organizations. Rather, these resources remain governed through separate institutional missions and funding channels. Public R&D funding is distributed across the defense, research, and economic-affairs portfolios, with defense historically accounting for only a limited share: before 2022, R&D absorbed around 2% of the German defense budget, compared with roughly 3.5% in France and some 15% in the United States (Quinet et al., 2025). At the same time, [SPRIND is not yet fully integrated into a broader security and defense innovation strategy](#). The government's July 2026 start-up and scale-up strategy, which places the opening of SPRIND to defense-relevant projects under review, points toward greater integration. Yet a 2026 acatech study reaches the same underlying diagnosis: [Germany's civilian and military innovation systems remain structurally separated and require more streamlined, cross-departmental innovation and procurement pathways](#).

This fragmentation becomes most visible at the interfaces between research, experimentation, and application. The absence of standardized pathways between academic research, industrial testing, and military use widens the gap between invention and innovation for impact. Without integrated test infrastructure and reliable transfer mechanisms, promising technologies can remain at the prototype stage or move into established industrial channels without generating independent new ventures. As discussed above, the limited conversion of innovation projects into Bundeswehr adoption, alongside scarce defense and dual-use sandboxes, reflects the same interface problem. These are not isolated shortcomings. They illustrate a broader coordination gap between research, testing, procurement, and industrialization.

These coordination frictions are reinforced by the regulatory layer that cuts across the same institutional interfaces. Firms operate within a multi-layered supervisory architecture in which national and European rules apply simultaneously and often according to different logics. Federal ministries, state authorities, and EU institutions exercise parallel oversight, creating the potential for redundant approval procedures and inconsistent requirements. In the production and export of military goods, firms must comply with the German War Weapons Control Act (KWKG), which imposes stringent national licensing obligations. At the same time, many contemporary defense technologies – particularly software, sensors, artificial intelligence, and other dual-use components – fall under the EU Dual-Use Regulation, with distinct approval pathways, transfer rules, and exemptions. The interaction of these regimes creates planning uncertainty and compliance complexity, particularly for start-ups and SMEs with limited administrative capacity. Better aligned and more streamlined regulatory pathways could therefore reduce the resources devoted to regulatory navigation and lower barriers to product development and market entry.

The coordination challenge also extends beyond research and government. Procurement, industrial policy, and finance are interdependent because the output of one becomes an input into another. A credible multi-year procurement commitment is simultaneously a demand signal for an IDE, a capacity signal for an SME supplier, a credit signal for a bank, and a risk-reduction signal for an equity investor. Conversely, uncertain call-off schedules or fragmented procurement pathways weaken investment incentives across the capital stack and industrial base. The preceding sections show that Germany has begun to strengthen each of these channels – through procurement reform, the Deutschlandfonds, a planned public equity vehicle for DSR start-ups, and growing

⁵ Notably, in September 2026, two weeks after the federal government attributed an attempted drone attack on Leipzig/Halle Airport to Russia, the Council adopted new measures against espionage, sabotage and attacks on critical infrastructure, agreed to reduce one-sided strategic dependencies and called for a swift revision of investment-screening law.

openness to new suppliers – but these instruments remain more effective when designed as complements rather than as parallel interventions.

Regional experience shows what stronger coordination can look like in practice. In Greater Munich, collaboration between Hensoldt, Quantum Systems, Airbus Defence and Space, and the Bundeswehr has progressed from joint experimentation toward system integration and strategic investment, while the Bundeswehr Innovation Center in Erding provides civilian innovators with a structured interface to military testing and procurement. The Rhineland/Ruhr area and northern Germany remain at earlier stages of the same development path, with greater emphasis on incubation, localization, external scouting, and institution-building. Effective national coordination should recognize these different stages and connect them into a broader system rather than applying uniform instruments across regions.

Germany has therefore recognized the need for greater coordination. Both the 2023 and 2026 security and military strategies emphasize interministerial coordination, but recognition and consultation are not yet equivalent to system-level orchestration. The National Security Council could provide an important forum for aligning strategic priorities, yet the broader governance challenge is less the absence of institutions than the absence of consistently strong mandates, interfaces, and incentives linking those that already exist. This distinction matters: information sharing can reduce duplication, but active orchestration requires the capacity to align R&D governance, innovation finance, industrial policy, and procurement around shared missions and to resolve conflicts between them. In the terms of the framework developed here, the unfinished coordination task is to ensure that government, industry, investors, and research institutions operate as parts of the same DSR market rather than as adjacent systems.

Institutional Culture

Formal coordination mechanisms alone are insufficient if the institutions expected to use them remain reluctant or unable to collaborate across established boundaries. Institutional culture therefore forms the behavioral foundation of coordination: it shapes whether public officials accept experimentation, whether universities engage with military users, whether primes treat start-ups as innovation partners, whether investors regard defense as a legitimate asset class, and whether entrepreneurs view DSR as a viable field in which to build companies. In Germany, these attitudes have historically been shaped by a post-war strategic culture marked by moral skepticism toward the use of military force and by durable firewalls between civilian and military activity (Bindenagel & Ackermann, 2018). [The prolonged political debate over armed drones illustrates how normative reservations could delay experimentation and adoption, weakening feedback between military users, technology developers, and procurement institutions.](#)

Since the *Zeitenwende*, however, the cultural narrative has shifted markedly. A Körber Foundation survey conducted in late 2024 found that 65% of Germans supported defense expenditure of 3–3.5% of GDP, a level that would have been politically difficult to imagine a decade earlier. A new generation of entrepreneurs has entered DSR, defense has become more visible in mainstream innovation discourse, and the political debate has shifted from whether Germany should rearm toward how it can do so effectively. Although the Bavarian Constitutional Court's 2026 ruling on civil clauses upheld such restrictions while safeguarding academic freedom, it nevertheless illustrates that the institutional boundaries governing security-relevant research are being actively renegotiated. These dynamics do not eliminate cultural reservations, but they create a substantially more open environment for DSR innovation than existed before 2022.

The remaining cultural constraints are therefore institutional rather than simply societal. Within government, weak circulation between public administration and industry limits exposure to commercial innovation models: fewer than 9% of senior civil servants in Germany have more than five years of private-sector experience (Kussel et al., 2024), a figure that places Germany near the bottom of European rankings. Liability rules reinforce this caution: BAAINBw project leaders are expected to enable innovation but have neither a legal safe harbor nor reliable senior-level backing should an experimental procurement decision fail, which favors established suppliers (Sawers, 2026); start-ups have accordingly called for limiting officials' – at least theoretical – exposure to official-liability claims in innovative procurement projects (STARK Defence, 2025).

Within research, civil clauses and divergent state- and university-level interpretations continue to shape whether technically capable institutions can participate in DSR projects, as discussed in the innovation-ecosystem section. Within industry, relationships between IDEs and large system integrators remain unsystematic and often dependent on individual initiatives, the same is true for the absence of dedicated military testbeds, while the 2025 German Startup Monitor reports that overall collaboration between start-ups and established firms has fallen to its lowest level in five years. Within finance, internal ESG and reputational policies as well as Basel regulations continue to discourage some investors and creditors from defense exposure.

These cultural frictions have hard economic consequences because they affect the connections among the building blocks of the DSR economy. Reputational concerns can deter entrepreneurs and investors; institutional firewalls can prevent research from reaching military users; risk-averse administrative practices can slow experimentation; and incumbent-oriented corporate routines can limit the absorption of external innovation. New entrants are often particularly exposed because they lack the organizational buffers, established customer relationships, and compliance capacity of large defense corporations. The result is not simply a slower innovation culture, but higher transaction costs at precisely the interfaces through which technologies move from research to commercialization, from start-ups to industrial systems, and from experimentation to procurement.

Germany therefore needs to consolidate the cultural shift already underway into durable institutional practice. A mission-oriented public narrative that links DSR innovation to technological leadership, economic resilience, and national security can reinforce legitimacy, but narrative alone is insufficient. The more consequential task is to align institutional incentives with the new political context: enabling collaboration across civil–military boundaries while protecting academic and entrepreneurial freedom, increasing tolerance for experimentation and iteration in public procurement, strengthening mobility and understanding between government and industry, and normalizing defense-related investment and entrepreneurship where legally and ethically appropriate. In this sense, institutional culture is not a separate constraint from coordination; it determines whether coordination mechanisms can work in practice.

Germany's remaining coordination challenge is less the absence of capable organizations than the quality of the connections among them. The country has demonstrated that political will and fiscal capacity can move individual parts of the DSR system quickly. The next phase of the *Zeitenwende* requires those gains to be institutionalized through mission-oriented orchestration that connects government, industry, investors, and research across the full innovation cycle. The unfinished business is therefore one of integration: turning a changed political and cultural context into durable routines that allow Germany's strong individual building blocks to function as a coherent DSR economy.

Conclusion

Since 2022 and the *Zeitenwende*, Germany has made measurable progress, in several respects historically unprecedented and comparatively impressive progress, in funding and building a DSR innovation economy that holds lessons for others in Europe, and wider NATO. As such, Germany's industrial legacy, economic structure, and record of technological development indicate that the country has key prerequisites to emerge as the central European hub for DSR innovation. This potential is not merely latent.

Fiscally, the politically-sensitive constitutional debt brake has been restructured to permit sustained DSR expenditure, and Germany has committed to meeting NATO's benchmark by 2029. This change would have been politically inconceivable a decade or even 5 years ago. These rapid changes since 2022 suggest a wider cultural change is afoot.

Against this backdrop, significant progress has been made. First, among IDEs, a new generation of deep tech firms – including Helsing, Isar Aerospace, Quantum Systems, STARK and ARX Robotics – has emerged with genuine international competitiveness and a strong vocal commitment to DSR. Munich has arisen as a globally-recognized DSR innovation ecosystem, with at least two others

clearly emerging in the country. More broadly, national Primes have scaled production capacity and connection to start-ups. In the capital markets, venture investment in German defense and dual-use start-ups nearly doubled in the first three quarters of 2025 relative to 2024. On the demand side, the government of Germany is starting to become an effective customer - sending clearly prioritized demand signals and starting to build procurement paths to make them a reality. Culturally, public and institutional attitudes toward DSR-related entrepreneurship and research have shifted meaningfully, even if deep-seated reservations persist. Germany's *Zeitenwende* has been made real, but the question this paper examined is whether it is yet sufficient.

Germany's *Zeitenwende* since 2022 constitutes the most significant reorientation of DSR policy since the founding of the post-war Bundeswehr. Viewed from a historical perspective, it is truly a remarkable achievement. A country that spent many decades systematically reducing its defense commitments, constraining its industrial base, and embedding normative restraints against military innovation has, within four years, restructured its constitutional framework, mobilized unprecedented fiscal resources, and begun cultivating a generation of defense-tech entrepreneurs capable of competing in the European theater.

That this transformation remains incomplete does not diminish what has already been accomplished. In an environment of systemic inter-state competition, however, the capacity to generate, integrate, and scale new technologies increasingly shapes national security outcomes alongside traditional military metrics.

Decades of declining domestic procurement demand, limited export incentives, and sustained security dependence on the United States produced an innovation architecture oriented toward maintenance rather than advancement. This grown structure, more than any recent policy failure, continues to constrain Germany's strategic adaptation. Our analysis suggests that Germany possesses many of the necessary elements: emerging ecosystems, a deep industrial base, and emerging financial markets. There is also a broader political acceptance of DSR as a strategic domain, making Germany a leading European contender for DSR innovation dynamics.

The challenge is not their absence but their integration. Rigid procurement processes, financing gaps, institutional fragmentation, and persistent cultural ambivalence toward defense innovation continue to favor incumbent structures over experimentation and adaptability. As a result, rising budgets risk reinforcing legacy production models and cost inflation rather than enabling the rapid iteration, systems integration, and production resilience required by contemporary conflict.

International comparison indicates that this outcome is neither inevitable nor primarily resource-driven. Successful ecosystems abroad, like Ukraine's DSR innovation ecosystem, have emerged through deliberate, emergency interventions that align state demand with entrepreneurial supply. At the same time, Ukraine's experience also underscores the limits of crisis-driven dynamism: sustaining innovation beyond acute conflict requires institutionalized strategies, diversified capital sources, and a stable governance framework. Germany's deep institutional foundations give it structural advantages that crisis-driven ecosystems lack. Germany's fragmented funding landscape, civil-military firewalls in academia, and risk-averse credit conditions complicate the alignment of innovators, capital providers, and military users. Yet, Germany has the institutional depth and multilateral links to address these systematically rather than reactively.

A DSR innovation economy also does not follow automatically from higher expenditure; it depends on intentional orchestration from entrepreneurs in innovation ecosystems into government, industry risk capital markets and beyond. Germany has demonstrated that it can move these stakeholders when political will aligns with institutional reform, as the post-2022 fiscal and legislative changes show. Without a mission-oriented architecture capable of sustaining that alignment, however, Germany's defense-industrial base will struggle to adapt at the pace required by the changing character of warfare, marked by autonomy, AI-enabled systems, cyber-physical integration, contested space and information domains, and unpredictable geopolitical developments.

Advancing the *Zeitenwende* further will require a shift in emphasis from fiscal spending and procurement reform alone toward ecosystem-building and strategic defense financing. This includes the development of testbeds and accelerated acquisition pathways for emerging technologies, the systematic integration of dual-use strategies, and a defense, security and resilience capital stack that supports firms from early development through scale-up, including access to guarantee-backed working capital. Several regional clusters already demonstrate the potential of such approaches, but their impact will remain uneven without stronger national coordination and enabling financial infrastructure.

More broadly, converting higher defense spending into durable military capability and economic returns will require treating DSR innovation policy as a central component of national grand strategy rather than a peripheral concern of the defense sector. This includes aligning Germany's financing architecture with an emerging allied consensus: that countries which coordinate financing efforts with trusted partners across the private and public sectors are better positioned to secure industrial capacity and long-term advantages by pooling capital. Such coordination is likely to rely increasingly on multilateral financing mechanisms capable of pooling and allocating capital at scale. For Germany, the strategic priority therefore lies less in sovereign borrowing than in leveraging guarantee and risk-sharing instruments for SMEs and growth-stage firms.

The *Zeitenwende* has succeeded, but it remains incomplete. Germany's role as a key pillar of NATO and European security will depend less on headline spending levels than on its capacity to cultivate innovation ecosystems that continuously generate, finance, and scale capabilities for deterrence. Whether the *Zeitenwende* develops into a sustained, innovation-driven strategic reorientation will hinge on Germany's ability to align financial resources with institutional reform and effective governance across both sovereign and multilateral innovation ecosystems.

Appendix 1: Lessons for Other Nations

Germany's rearmament over the past four years offers insights that extend well beyond its own borders. For nations across Europe and beyond, there are six overarching lessons for those with the necessary 'political will' to strengthen their DSR innovation ecosystems in response to an increasingly contested security environment.

Lesson 1: Political will and fiscal commitment are necessary, but system design determines what the spending produces.

Germany demonstrates how quickly political will and fiscal capacity can mobilize a national DSR economy. When accompanied by fiscal capacity, progress can be made. And yet fiscal expansion is an input, not an outcome: higher budgets routed through fragmented institutions, rigid procurement systems, or capacity-constrained supply chains can reinforce incumbent structures and price pressures rather than generate additional capability. For other nations, the implication is that fiscal commitment should be accompanied from the outset by clear statements of political intent as well as institutional reforms that determine where resources flow, which firms can access them, and how rapidly expenditure can be converted into production, innovation, and readiness. Spending more is necessary; spending differently is essential and is perhaps what is hardest in complex political systems.

Lesson 2: Use sovereign credit strength to drive fiscal commitments.

Germany's decision to leverage its strong sovereign balance sheet to finance higher defense expenditure allows it to align political will with ambitious fiscal commitments. Germany remains one of Europe's most creditworthy sovereign borrowers- retaining AAA ratings and benefiting from its position as the euro area's benchmark issuer. Other nations do not necessarily enjoy Germany's financing advantage and should thus treat access to low-cost capital as part of their DSR strategy. EU Members can use instruments such as SAFE, which provides up to €150 billion loans for defense investment. More broadly, the Defence, Security and Resilience Bank offers a complementary model: a sovereign-owned multilateral bank with its own AAA rating would allow participating allies and partners to pool credit strength and obtain long-term DSR financing. Other approaches include the MDM. The broader lesson is that countries should finance DSR through the cheapest balance sheet available –national where sovereign credit is strong, multilateral where pooling credit strength can materially lower the costs.

Lesson 3: Demand only matters when strategic signals become testable and bankable orders.

Strategies, capability priorities, and larger budgets can orient a market, but alone, they do not activate it. Germany's experience shows that the decisive step is the conversion of strategic demand into pathways for experimentation, validation, and procurement that culminate in orders. Procurement should therefore be designed as an innovation instrument, not merely an acquisition mechanism. Dedicated testbeds can allow emerging technologies to be validated under near-operational conditions; modular and milestone-based acquisition can accommodate the iteration cycles of innovation-driven enterprises (IDEs); and multi-year procurement frameworks with credible call-off schedules can provide the certainty required for firms, suppliers, and financiers to invest ahead of demand. For other regions, the order is the point at which political intent becomes industrial revenue, capacity expansion, and further private investment.

Lesson 4: Strong innovation ecosystems and components of an industrial base do not compensate for weak interfaces.

Regional innovation ecosystems can galvanize research outputs, entrepreneurial talent, industrial capacity, and capital. Germany possesses many of these assets in depth, yet their impact varies according to how effectively research institutions connect to entrepreneurs, start-ups to prime contractors, regional ecosystems to military users, and experimentation to procurement. The German regional experience also shows that policy instruments should reflect ecosystem maturity rather than be applied uniformly: a region already capable of system integration requires different interventions from one still building basic institutional interfaces. For other nations and regions, the lesson is to invest deliberately in the connective infrastructure of innovation – testing access, transfer mechanisms, open industrial interfaces, procurement gateways, and cross-regional coordination – rather than assuming that spatial proximity or institutional quality will generate collaboration automatically.

Lesson 5: The capital stack must be designed around the economics of DSR.

A functioning DSR economy requires more than venture capital or larger sovereign budgets. Different firms need different forms of capital at different stages: early-stage risk capital for technology development, growth equity for scale-up, bank credit and working capital for suppliers, and guarantees or risk-sharing where long procurement cycles, asset specificity, regulation, and uncertain cash flows constrain conventional lending. Germany's experience also shows that financing and procurement cannot be treated as separate policy domains: a credible multi-year order can reduce risk for an equity investor, strengthen a supplier's borrowing capacity, and justify investment in production capacity. For other regions, public financing instruments should therefore be designed as complements within a layered capital stack, with guarantees and risk-sharing reaching deep into supply chains and public equity used selectively so as to mobilize rather than crowd out private capital.

Lesson 6: Orchestration and institutional culture are strategic infrastructure.

Distributed or federal governance structures are not inherently incompatible with an effective DSR economy, but they require deliberate orchestration across institutional silos. Information sharing and interministerial consultation are not sufficient where procurement, R&D governance, industrial policy, innovation finance, and regional development pursue separate objectives. Effective orchestration requires clear mandates, resources, and decision rights capable of aligning these functions around shared missions. Formal mechanisms, however, work only when institutional culture permits collaboration. Germany's post-2022 experience shows that public attitudes toward defense innovation can shift faster than the routines of universities, administrations, investors, and established firms. For other nations, cultural legitimation should therefore be treated as part of the innovation architecture itself: political leadership can create permission for security-relevant entrepreneurship and research, but durable change requires that this new context be embedded in institutional incentives, greater tolerance for experimentation, more open civil–military collaboration, and the normalization of legally and ethically appropriate DSR investment and entrepreneurship.

Appendix 2: Additional Tables

Table A3: Macroeconomic Profile of Germany

Indicator	Value / Description
<u>Population</u>	83.6 million
<u>Employment (2024 average)</u>	46.1 million
<u>Unemployment rate (2024)</u>	6%
<u>GDP (2024)</u>	€ 4,305 billion (3rd globally; 1st in Europe) € 50,827 GDP per capita
<u>GDP Growth (2024)</u>	-0.2%
<u>Debt Ratio (2025)</u>	63.2% of GDP
<u>Credit Ratings (2024/25)</u>	AAA (S&P) / Aaa (Moody's) / AAA (Fitch) Long-term Ratings
<u>Sectoral Composition (2024)</u>	Services: 70.6% of GDP, Production industry: 28.5% of GDP, Agriculture: 0.9% of GDP
<u>Export Share (2024)</u> <u>Trade Balance (2024)</u> <u>Top Export Categories (2024)</u>	41.8% of GDP Surplus of € 241.2 billion #1 Vehicles (17%), #2 Machinery (16%), #3 Electronics (11%), #4 Pharmaceuticals (7.5%)
<u>SME (Mittelstand) Share/ Contribution/ Employment (2022)</u>	99.2% of all firms; 55% of private sector net value added 19 million
<u>Biggest Corporates (Mkt Cap 2024)</u>	SAP, Siemens, Deutsche Telekom, Allianz, Munich RE, Siemens Healthineers, Merck, Mercedes-Benz, Porsche, BMW
<u>R&D Expenditure (2023)</u>	3.1% of GDP
<u>Patent Applications (2024)</u>	709 per million inhabitants
<u>Start-up Formations (2024)</u>	2,766 in total
<u>FT1000 Europe's Fastest-Growing Companies (CAGR 2020-23)</u>	158 out of 1000 companies
<u>Dealroom Unicorn-Ranking per capita (2024)</u>	#21 out of 50 countries
<u>Venture Capital per capita (2024)</u>	\$ 91
<u>European Innovation Scoreboard (2024)</u>	Innovation output growth below EU-average
<u>Industrial Competitive Advantages</u>	Automotive, mechanical engineering, green tech

**Table A4: Relative Military Capacity and Defense Effort
(Germany, United Kingdom, and France, 2024/25)**

Indicator	Germany	United Kingdom	France
Active military personnel (2024, NATO estimate)	185,600 <i>Source: NATO Defence Expenditure 2014-2025</i>	138,100 <i>Source: NATO Defence Expenditure 2014-2025</i>	204,700 <i>Source: NATO Defence Expenditure 2014-2025</i>
Operational / volunteer reserve (2024, national definitions)	49,244 assigned reservists (beorderte Reservistinnen und Reservisten); 20,074 reservists performed reserve duty during 2024. <i>Source: Bundestag - Annual Report of the Parliamentary Commissioner 2024</i>	32,490 Future Reserves 2020 personnel (trained + untrained) on 1 April 2024; approximately 29,570 trained across the Maritime, Army and RAF Reserves. <i>Source: UK MOD - Quarterly Service Personnel Statistics, 1 April 2024</i>	44,000 reservists under the Ministry of the Armed Forces as of 1 August 2024. <i>Source: French National Guard / Ministry of the Armed Forces</i>
Defence expenditure (2024, NATO definition; current prices)	EUR 86.638 bn (approx. USD 93.747 bn) <i>Source: NATO Defence Expenditure 2014-2025</i>	GBP 65.841 bn (approx. USD 84.164 bn) <i>Source: NATO Defence Expenditure 2014-2025</i>	EUR 59.580 bn (approx. USD 64.469 bn) <i>Source: NATO Defence Expenditure 2014-2025</i>
Defence expenditure as % of GDP (2024, NATO estimate)	2.00% <i>Source: NATO Defence Expenditure 2014-2025</i>	2.33% <i>Source: NATO Defence Expenditure 2014-2025</i>	2.03% <i>Source: NATO Defence Expenditure 2014-2025</i>
Major-equipment share of defence expenditure (2024)	21.17% <i>Source: NATO Defence Expenditure 2014-2025</i>	33.36% <i>Source: NATO Defence Expenditure 2014-2025</i>	28.50% <i>Source: NATO Defence Expenditure 2014-2025</i>
Nuclear deterrence	No national nuclear arsenal; participates in NATO nuclear-sharing arrangements. <i>Source: NATO - Nuclear deterrence policy and forces</i>	Nuclear-weapon state with an independent national deterrent that contributes to NATO deterrence. <i>Source: NATO - Nuclear deterrence policy and forces</i>	Nuclear-weapon state with an independent national deterrent; France does not participate in NATO's Nuclear Planning Group. <i>Source: NATO - Nuclear deterrence policy and forces</i>
Geostrategic / alliance role	Central European logistics and reinforcement hub for NATO ("Drehscheibe Deutschland"); major role in rapid reinforcement and the eastern flank. <i>Source: German Federal Government - NATO overview</i>	Framework nation of the Joint Expeditionary Force (JEF), focused on the Baltic Sea region, High North and North Atlantic; strong expeditionary and maritime posture. <i>Source: UK Government - Joint Expeditionary Force</i>	Continental, Atlantic and Mediterranean position plus overseas territories and a permanent strategic presence in the Indo-Pacific. <i>Source: French Ministry of the Armed Forces - Indo-Pacific strategy</i>
NATO commitment (agreed 2025)	At least 3.5% of GDP for core defense requirements plus up to 1.5% for broader defense- and security-related investment by 2035. <i>Source: NATO - 5% commitment</i>		
National spending trajectory	Plans to reach 3.5% of GDP in NATO-defined core defense spending by 2029, ahead of the Alliance-wide 2035 horizon. <i>Source: German Federal Government - NATO overview</i>	Defense spending to reach 2.5% of GDP by 2027; about 2.6% when relevant intelligence and security expenditure is included, with an ambition to reach 3% in the next Parliament. <i>Source: UK Government - 2.5% by 2027: Prime Minister statement - 2.6% incl. intelligence</i>	National defense budget planned to reach EUR 64 bn in 2027, twice the 2017 level. <i>Source: Élysée - address to the armed forces, 13 July 2025</i>

**Note: For cross-country comparability, active personnel, defense expenditure, GDP share and the equipment share use the same NATO 2024 series. Reserve figures remain based on national definitions and are therefore less directly comparable. The German national year-end headcount (181,174 active personnel) differs from NATO's 2024 estimate (185,600) because the underlying definitions and reporting conventions are not identical.*

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