NOTE

PROGRAMME DEFENCE AND HIGH TECHNOLOGY INDUSTRY

LOW-COST SOLUTIONS FOR MILITARY CAPABILITIES

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PROGRAMME
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INTRODUCTION

Over the past 50 years in Western Defence and Technological Industrial Bases (DTIBs), **rising costs have outpaced increases in defence budgets**[1], thus limiting the number of systems armed forces can afford to procure. This "scissor effect", as explained by Ténenbaum, is pushing Western armed forces toward smaller and more limited forces: an observation in line with Augustine's 1984 Law, which highlights the increasing financial cost of maintaining cutting-edge military technologies[2]. On the contrary, confronted with limited financial resources, increasing economic sanctions, and less advanced technology, **adversaries are turning to strategies based on mass and saturation**. In ongoing conflicts like the war in Ukraine, the development of low-cost military capabilities has, therefore, become a crucial focus; not only for adversaries such as Russia and Iran, but also for Ukrainian forces themselves. **Countries are now increasingly looking for affordable ways to counter advanced weapons to sustain military efforts**. Published recently, the U.K.'s 2025 Strategic Defence Review underscores just that. Future warfare will be shaped by "an evolving mixture of high- and low-end military capabilities"[3]. This change will, in turn, **redefine the "economics of defence"**[4], with low-cost weapons playing a key role in damaging or depleting expensive military assets[5]. In line with this, the French Parliamentary Report of June 2025 emphasizes how low-cost military and civilian solutions enhance saturation capabilities[6]. However, the report also highlights that the widespread use of commercially available, **low-cost tools poses a significant challenge**: it has "narrowed the technological gap between state and non-state actors" [7], raising new concerns about the future of defence. As **Western countries' defence industries have not originally been designed for low-cost production**, defence strategies are facing important challenges. The global rise of low-cost solutions thus forces a **re-evaluation of traditional models**, eliciting major debates between scholars, policymakers, and industrials alike.

To bring this out more clearly, this note will first examine the conceptual framework of the low-cost model, clarifying its semantic ambiguities, principles, and strategies. It will then

[1] Quin, É. 2025. "Salon du Bourget : la course à l'armement inéluctable pour le monde entier ?". In *28 minutes.* KM Production & ARTE Radio.
[2] Wallaert, D. 2017. "La loi d'Augustine est-elle une fatalité pour les armées françaises à 10 ans ?" In *Cahiers de la Revue Défense nationale – Penser demain*, p. 207.
[3] UK Strategic Review. 2025. *Global Britain in a Competitive Age: The Integrated Review of Security, Defence, Development and Foreign Policy.* HMSO, p. 29.
[4] Ibid.
[5] Ibid.
[6] Gassilloud, T., and D. Girard. 2025. *Rapport d'information déposé en application de l'article 145 du Règlement par la Commission de la Défense nationale et des forces armées : Masse et haute technologie : quels équilibres pour les équipements militaires français ?,* Assemblée nationale, p. 20.
[7] Ibid.

evaluate low-cost solutions within the defence market, identifying production, conception, and design strategies in order to critically assess the challenges and obstacles inherent to low-cost solutions for military capabilities. The last section of this note will be dedicated to recommendations, emphasizing the role of **low-cost as a complementary tool rather than a substitute for advanced capabilities and its use in specific domains**. That being said, before going into the specifics, a key distinction should be made between “low-cost economics” and “low-cost capabilities”. This note is interested in the latter. It is crucial to clarify that the goal is not to advocate for low-cost at the expense of operational effectiveness but to balance high-end and low-cost solutions in specific military arsenals.

LOW-COST: A CONCEPTUAL FRAMEWORK

Clarifying semantic ambiguity

A broadly agreed-upon definition of low-cost refers to “**products or services designed to be affordable without substantially compromising functionality or quality**”[8]. Yet, there remains considerable semantic ambiguity in defining the term. Indeed, “low-cost” is muddled with linguistic and conceptual nuances, both among researchers and practitioners. Clarifying the varying understandings that may arise from it is, therefore, essential.

First, merely cutting costs does not automatically qualify a product or service as low-cost[9]. While low-cost products imply an absolute level of affordability, **lower-cost** or **cost-efficient** products only imply reduced prices in comparison to existing market standards. More importantly, there is an important distinction to be drawn between **price** and **cost**. Whereas price corresponds to what consumers pay, cost corresponds to the expenses borne by the producer. In this light, the Beigbeder Report[10] stresses that true low-cost approaches cannot be confused with superficial **price cuts** that fail to reflect **cost reductions**. In turn, low-cost solutions stand out in the reduction of both costs and prices. Third and equally important, low-cost solutions also **redefine and simplify the product** to achieve greater efficiency[11]. Fourth, low-cost solutions are part of a broader strategy potentially restructuring the business model and reshaping supplier–customer relationships. As such, low-cost is not merely a commercial

[8] Rivière, M., M. Bonneveux, et al. 2017. *Les stratégies low-cost : synthèse et perspectives*. *Revue française de gestion*, Éditions Lavoisier, p. 74.
[9] Combe, E. 2013. *Le low-cost : une révolution économique et démocratique*. Fondation pour l’Innovation politique, p. 6.
[10] Beigbeder, C. 2007. *Le « low cost » : un levier pour le pouvoir d’achat*. Report submitted to Luc Chatel, Secretary of State for Consumer Affairs and Tourism, p. 3.
[11] Rivière, M. *et al*. 2017.

or a production strategy, but a full-fledged **business model**[12]. A last point worth mentioning is the **difference between low-cost and low-tech**, which lies in their respective objective and approach. While low-cost primarily focuses on reducing expenses with the aim of profitability, low-tech[13] emphasizes simplicity, using low technology often to minimise environmental impact.

In the defence sector, the concern for cost is far from new. Decades ago, industry executives were already raising concerns about unsustainable defence spending trends. Former Lockheed Martin CEO, Norman Augustine, observed the exponential rise in military aircraft costs[14] and satirised this trend in what is now known as **Augustine's Law**. As Augustine argued, "in the year 2054, the entire defence budget will purchase just one tactical aircraft"[15], a principle which has proven to be universal. A 2024 analysis from the Center for Strategic and International Studies (CSIS) noted that **modern fighters follow an "Augustinian" trendline**[16]: the rise in military aircraft costs is exemplified in programmes like the Air Force's *F-22*s and *F-35*s. The *F-35* programme, for instance, became the most expensive weapons project in history, with an estimated life-cycle cost of USD1.3 trillion and development running seven years behind schedule and USD163 billion over budget[17]. The loss of a single *F-35* can, therefore, have dramatic impact because of expensive replacements and slow procurement.

As such, for decades, Western armies have relied on **technological superiority and highly sophisticated weapons, even if it meant having small quantities**. Question is: have they wrongly focused on developing the 'ultimate' defence equipment? The war in Ukraine has not only highlighted the **need for large volumes** of ammunition and drones, which are replacing traditional combat aircraft. As exemplified by Ukraine's Spiderweb[18], the increasing reliance on drones in modern warfare is reshaping military strategy. It also demonstrates the **limitations of relying exclusively on high-end weapons systems** that are costly and time-consuming to produce. Today, stockpiles are quickly depleted, and traditional production lines, designed for peacetime, struggle to keep up. This growing awareness has renewed interest in low-cost solutions and in a **war economy mindset**. A strategic shift is thus emerging: **integrating more civilian players into the defence industrial base, designing weapons that**

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[12] Ibid, p. 73.
[13] Académie de défense de l'École militaire. 2024. *Libres réflexions n°3 – Épuisement des ressources : vers une armée de Terre low-tech ?* Ministère des Armées, p. 1.
[14] Calhoun, P. 2016. "DARPA Emerging Technologies." *Strategic Studies Quarterly*, p. 112.
[15] Wallaert, D. 2017, p. 207.
[16] Allen, G. C., and I. Goldston. 2024. "Updating Augustine's Law: Fighter Aircraft Cost Growth in the Age of AI and Autonomy." Center for Strategic and International Studies. Link
[17] Sadler, B. D. 2016. "Fast Followers, Learning Machines, and the Third Offset Strategy." *Joint Force Quarterly* 83: 13–18. National Defense University Press, p. 13.
[18] NBC News. 2025. "Ukraine's Spiderweb Drone Attack on Russia: How Kyiv Used Satellite Intelligence." *NBC News*. Link.

are scalable and adaptable instead of perfect, and placing mass production back at the center of military planning.

Implementing the low-cost model: Principles and strategies

Understanding the roots, principles, and strategies of the low-cost model is essential to grasp the complexity of adopting low-cost solutions for military capabilities. Indeed, low-cost strategies are far from monolithic. **Different organisational cultures, social climates, and market conditions can shape low-cost strategies**. In an insightful report, Brillet and Rivière[19] suggest that low-cost strategies come in many forms: "Hard low-costers" offer a heavily simplified product or service while "middle low-costers" offer moderate simplification with some baseline services. As for "soft low-costers", they offer minimal simplification and not necessarily advertise themselves under the low-cost banner. In each scenario, however, the strategies are **demand-driven and reassess consumer needs**.

Low-cost strategies typically involve a range of core principles[20]:

- **Cost efficiency:** Effective cost efficiency involves **eliminating processes that do not add value to the final product**[21]. For example, in April 2025, Spanish firm Indra developed a new *Chinook CH-47F* full-mission simulator. This new simulator reduces the number of flight hours required for crew instruction by up to 40 %, which contributes to **lower operational and maintenance costs**[22].
- **Economies of scale:** As production volume increases, the cost per unit naturally decreases. **This advantage enables firms to charge lower prices** while still preserving profit margins. A convincing example is the recent announcement from the Greek government about receiving additional US-made *Switchblade 300* and *Switchblade 600* drones. Indeed, U.S. manufacturer AeroVironment is ramping up production. Thus, costs have been lowered, and more drones could be acquired under the existing budget[23].
- **Frugal innovation:** This strategy involves focusing on essential features, simplifying the offer, and **eliminating non-essential features**. That way, companies can create products that meet customer needs at a significantly reduced cost[24]. Turkiye's

[19] Coutelle-Brillet, P., and Rivière, A. 2014. « Et si 'moins' signifiait 'mieux' : la valeur perçue d'une offre low-cost ». *Décisions Marketing*, no. 73, p. 71.
[20] Rivière, M. *et al*. 2017.
[21] Jaouen, A. 2023. *Le modèle low-cost : propositions pour la défense*. Ministère des Armées, Conseil Général de l'Armement.
[22] Indra. 2025. "The Spanish Minister of Defense Visits Indra's New Chinook CH-47F Simulator, Europe's First for the New Version of This Helicopter." Link.
[23] Nedos, V. 2025. "Greece Eyes Additional US Drones." *eKathimerini.* Link.
[24] Rivière, M. *et al*. 2017.

Bayraktar TB2 drone is a prime example of frugal innovation. The TB2 focuses only on essential surveillance and strike capabilities, using commercial off-the-shelf components[25].

The key parameters that emerge from the strategies above thus revolve around **cost, simplicity, quantity, and demand**. In addition, low-cost offerings often lead to a disruption of existing competitors and an intensification of market competition. By challenging established norms and cost structures, low-cost players, therefore, confront two principal forms of **competition**: **from both traditional businesses and other low-cost operators**.

A disruptive and transformative strategy? An economic revolution? … Or both?

Our reflection on low-cost as a societal phenomenon raises a central question: **to what extent do low-cost solutions represent a break in production, consumption and sales, in both mindsets and habits?** Much ink has been spilled on the topic, eliciting a major debate as to whether low-cost solutions should be considered a disruptive strategy or a full-fledged economic revolution rooted in structural factors.

On the one hand, low-cost strategies **redefine industry rules**, change long-established business models, alter companies' value-chains, destabilise traditional players, and intensify market competition[26]. Going further in this analysis, low-cost solutions can be considered **disruptive *and* transformative**. Indeed, low-cost reshapes competition, expands consumer bases, and creates new avenues for value across many industries. On the other hand, however, some argue that reality is far more complex than it appears[27]. The success of the low-cost model cannot be solely attributed to the economic context. Some, therefore, consider it a full-fledge "economic revolution". The low-cost model is **a structural rather than a temporary trend**; low-cost behaviours being likely to continue even after an economic crisis. In this view, low-cost is a **radical model**, which prompts a deeper understanding of how certain goods and services should be produced, marketed, and delivered. In essence, the low-cost paradigm brings about fundamental **shifts in strategic thinking**. Hence, whether interpreted as a game-changing disruption or an economic revolution, **it is indisputable that low-cost solutions lead to an enduring and structural transformation in markets and society**.

While the low-cost model is not a new concept, its application in the defence sector brings important questions about how it can be adapted and implemented effectively. Rather than

[25] Honrada, G. 2022. "The Turkish Drones Winning the Ukraine War." *Asia Times.* Link.
[26] Lehmann-Ortega, L., and P. Roy. 2009. "Les stratégies de rupture : synthèse et perspectives". *Revue française de gestion*, p. 114.
[27] Rivière, M. *et al*. 2017.

introducing a completely novel approach, **the real challenge lies in finding ways to adjust this model to defence needs while maintaining operational efficiency**. In other words, this **transition** is not about completely disrupting existing frameworks but rather about **refining established principles to address modern warfare's specific demands**. Thus, adopting low-cost solutions for military capabilities within the European arms industry will certainly involve significant adjustments to better meet contemporary requirements.

LOW-COST SOLUTIONS IN THE DEFENCE MARKET

What are the lower-cost methods?

While **lower-cost approaches do not make a product low-cost**, defence firms integrate lower-cost methods in conception, production and strategic planning as they are essential to develop low-cost military capabilities. Put differently, low-cost is a full-fledged **business strategy**[28] **that requires, but is not limited to, lower-cost methods**.

- **Leveraging the civilian sector**

Open Innovation (OI)

In defence innovation, the European Defence Industry is now operating on a "quintuple helix innovation model"[29] with the involvement of academic institutions, research labs, startups, SMEs, and governments[30], rather than relying **solely** on its R&D departments. From this approach – while not intending to originally significantly reduces costs – emerged a strategy called "Open Innovation"[31] (OI). In other words, it means **moving from outsourcing** Research, Development, and Innovation (R&D&I) activity, to **integrating external competencies**.

Italian firm Leonardo is one of many that uses this method with the Leonardo Labs Initiative to accelerate the development of advanced defence technologies like AI and autonomous systems. By leveraging partnerships with startups and universities, Leonardo **reduces internal R&D costs**, thus making it a lower-cost strategy in developing military capabilities. While initiatives like the Leonardo Labs demonstrate how defence firms leverage external expertise

[28] Ibid.

[29] The Quintuple Helix Model is an evolution of earlier "helix" frameworks (Triple, Quadruple) that describe the relationships driving innovation in modern societies. The Triple Helix included only universities, industry and government; the Quadruple Helix added civil society while the Quintuple Helix extended the innovation landscape to environment and ecosystem, recognising that sustainable development and ecological constraints must be part of any innovation ecosystem.

[30] Reis, J., N. Melão, J. Costa, and B. Pernica. 2022. "Defence Industries and Open Innovation: Ways to Increase Military Capabilities of the Portuguese Ground Forces." *Defence Studies.*

[31] Chesbrough, H. W. 2003. *Open Innovation: The New Imperative for Creating and Profiting from Technology.* Harvard Business School Press, p. 58.

to reduce costs, they also raise broader questions about **whether these Open Innovation strategies fundamentally alter the industrial model or simply optimise existing processes**.

Dual-use technologies

Furthermore, incorporating **dual-use technologies from SMEs and startups** can significantly reduce both the cost and development time of defence systems. By leveraging commercially mature solutions, defence firms not only cut down on R&D expenses but also benefit from faster innovation cycles and greater adaptability in system design. Civilian companies are also capable of driving technological breakthroughs[32] by offering reliable, low-cost products. For example, the French Ministry of the Armed Forces has developed the "**Action PME Plan**," which helps reduce the costs of defence equipment and services as SMEs can often develop and produce the same product at a significantly lower price than a large group. In the aerial and drone sector, startups like Novadem received diagnostics and export support from the DGA under "Action PME" to industrialise its low-cost *NX70* reconnaissance drone.

Production techniques from the commercial sector

In addition, U.S. defence companies are increasingly looking at **techniques** from the commercial sector. An illustrative example is defence tech firm Anduril Industries, which, in 2024, announced a novel "hyperscale weapons factory"[33]. In practice, this meant using widely available **commercial components and materials wherever possible and using iterative prototyping in production**. In other words, Anduril continuously evolves the product on the assembly line instead of perfecting the design. Commercial high-rate production techniques (like automated assembly and additive manufacturing)[34] are being adapted to defence not only enabling rapid manufacturing but also helping support low-cost sustainment.

Nevertheless, the adoption of commercial production techniques in defence raises an important question: **are these methods truly cost saving, or do they simply redistribute expenses?** While Anduril Industries' weapons factory demonstrates how defence firms integrate commercial components and iterative prototyping to streamline production, the broader economic impact remains complex. For instance, Anduril's approach emphasizes low-cost, high-volume manufacturing, particularly with autonomous systems like the Roadrunner. By leveraging commercially available materials and AI-driven automation, the company

[32] Gianfortune, R. 2025. "DOD's Tech Advantage Hinges on Commercial Collaboration, Says DIU Director." *GovCIO Media & Research.* Link.
[33] Anduril Industries. 2024. "Anduril Raises $1.5 Billion to Rebuild the Arsenal of Democracy." Link.
[34] America Makes. 2023. *Rapid Response Solutions Support AM Technologies for Low-Cost Sustainment.* Link.

reduces reliance on expensive components. However, **cost-effectiveness is not solely about production, it also depends on sustainment and operational efficiency**.

- **Design, conception, and production techniques**

Modular Open Systems Approach (MOSA)

Developing low-cost weapons that can be produced in mass has become a strategic advantage for countries like Ukraine (FPV Kamikaze drones) and Turkiye (Bayraktar TB2 drones). A key enabler of low-cost capability lies in innovative conception and design techniques by embracing, for example, **modular, flexible designs and open architectures**[35]. The Modular Open Systems Approach (MOSA) emphasizes common standards so that subsystems can be easily **added, replaced, or reused**[36] across different platforms, thus **lowering life-cycle costs**. Indeed, this technique avoids the military to spend on costly parts. MOSA's benefits, in particular, include improving interoperability, enhancing competition, facilitating technology refresh, incorporating innovation, and enabling cost savings[37]. Likewise, as explained by Hérault in this thesis, Naval Group's Gowind family including corvettes and offshore patrol vessels (OPVs) is a prime example of the MOSA principle applied to naval platforms[38].

Table 1 – MOSA principle: Naval Group's Gowind family

MOSA	Description – Gowind family
Modular design	Feature mission modules can be swapped or upgraded (*i.e.*, anti-submarine warfare, surveillance, air defence)
Open architecture	Uses open electronic warfare and combat systems interfaces (such as SETIS Combat Management System)
Scalable platform	Uses basic patrol versions or fully armed corvettes, depending on customer needs
Local industry integration	Can be co-produced with local shipyards (*i.e.*, Malaysia, Egypt), allowing for national customisation and technology transfer

Source: IRIS

In November 2024, Naval Group signed a Memorandum of Understanding (MoU) with Thales and KNDS to work on integrating their solutions into the Multipurpose and Modular Launching

35 U.S. Government Accountability Office. 2025. *Weapon Systems Acquisition: DOD Needs Better Planning to Attain Benefits of Modular Open Systems.* GAO-25-106931, p. 3.
36 Ibid, p. 11.
37 Bier, V. M., and A. Gutfraind. 2019. "Open Systems in Military Procurement: Reducing Costs and Improving Interoperability." *Journal of Defense Modeling and Simulation*, p. 6.
38 Hérault, P. 2018. *L'internationalisation des chaînes de valeur dans l'industrie de défense : le cas du naval*. Université Paris Sciences et Lettres, p. 299.

System (MPLS)[39]. By incorporating interchangeable ammunition modules, the MPLS allows for the deployment of various munitions (such as rockets, missiles, grenades, underwater weapons, decoys, and UAVs) **from a single launcher, facilitating rapid reconfiguration to meet diverse mission requirements**. This modularity uses the Modular Open Systems Approach to reduce life-cycle costs. Another convincing example is Anduril Industries' Counter Unmanned Aerial System (CUAS) Engagement System (CES), developed for the U.S. Marine Corps.

The **European Component Oriented Architecture (ECOA)** norm, developed by Dassault Aviation and BAE Systems, aims to reduce the cost and development time of embedded software and **to facilitate the implementation of modular weapon systems**[40]. For now, the ECOA standard is limited to the avionic systems of military aircraft (Rafale, SCAF, etc.) and could usefully be extended to European naval and land weapon systems[41].

Simplification

Simplification is a key method in reducing the costs of products and services. The goal of simplification is to lower operational costs and, ultimately, the prices charged to users. However, simplification efforts must be carefully evaluated as **they can require expensive redesign or requalification**. In other words, they will only be cost-effective if they result in a **significant reduction in the production price**. The Safran AASM missile programme demonstrates the challenges of cost control: despite efforts to reduce expenses, initial unit costs were very high. Yet, through **simplication, iterative redesigns and production scaling**, the cost of the AASM Evolution reportedly dropped from EUR252,000 to EUR120,000, with a target of EUR80,000[42]. As such, this shows how **sustained focus on lower-cost methods can gradually align advanced systems with affordability goals**.

Digital engineering and design tools

In addition, many Western countries have adopted digital engineering and AI-driven design tools to accelerate development and cut costs. Modern programmes increasingly use computer models, simulation, and digital prototypes to design and test systems virtually[43]. **By catching design flaws, programmes can avoid the traditional cycle of multiple physical prototypes**, which is a costly and time-consuming process. For instance, Additive

[39] Naval Group. 2024. "Multi-purpose and Modular Launching System (MPLS): Naval Group Joins Forces with Thales and KNDS to Develop This New Equipment." Link.
[40] Jaouen, A. 2023. p. 58.
[41] Ibid.
[42] Cabirol, M. 2017. "AASM Evolution, la nouvelle bombe low-cost de Safran". *La Tribune.* Link.
[43] Keller, J. 2021. "Air Force Turns to Digital Twin Technology That Uses Virtual Representations of Real Objects for Prototyping." *Military & Aerospace Electronics.* Link.

Manufacturing, commonly known as 3D printing, can refine the design in cycles[44]. **This "fly, fix, fly" technique, borrowed from software development, contrasts with the old paradigm of programmes that tried to get it perfect in one go.** A striking example is the U.S. Air Force Research Lab's XQ-58A Valkyrie UAV – part of the Low Cost Attritable Aircraft Technology (LCAAT) project – which went from contract to first flight in only two and a half years. The Valkyrie was developed using digital design tools and commercial manufacturing processes to ensure a "low cost, low maintenance, more expendable platform"[45].

Moreover, **Model-Based Systems Engineering** (MBE) in defence **replaces fragmented, document-centric workflows with a unified, model-centric approach**. It enables all stakeholders to be aware of requirements, define system architectures, and simulate mission scenarios in an interconnected environment. Among other things, it **helps reduce development and integration costs and enables rapid feedback on life-cycle cost**. For example, BAE Systems explicitly leverages MBE to drive down costs in several of their air-and-missile defence projects, especially to develop low-cost interceptor solutions. Another clear case is Sweden's Saab which has incorporated MBE across its product lines (*i.e.*, Gripen fighter).

Questioning low-cost solutions in the defence sector: Challenges and obstacles

However, evaluating low-cost solutions for military capabilities needs a more sceptical evaluation. This entails unpacking the economic logic of "low-cost" in order to expose weaknesses. Indeed, the issue is not **low-cost strategies themselves**, but rather how they are **applied**. Thus, it is essential to **distinguish between the low-cost economic model and low-cost military solutions**. **In defence, low-cost strategies should focus on ensuring reliability, effectiveness, and adaptability rather than simply reducing costs**. If affordability becomes the main goal, systems may lose durability, performance, or integration capabilities, creating weaknesses in national security.

- **Sustainability of the economic model**

Deferred maintenance and hidden life-cycle costs

Short-term savings must not lead to higher maintenance or replacement costs in the long run. Indeed, the drive for "low-cost" solutions in defence can often mask significant deferred costs, both financial and strategic, that emerge over a system's life-cycle. **Deferred maintenance**

[44] Defense Logistics Agency. 2019. *Small Business Innovation Programs: Explored Innovations Securing Resources for U.S. Defense & Commercial Industries.*
[45] University of Dayton Research Institute. *Low-Cost Attritable Aircraft Technology (LCAAT) Capabilities.*

costs, for example, occur when scheduled inspections or specific replacements are often postponed because a platform was developed as a low-cost solution with **limited sustainment budgets**. Deferred maintenance **leads to unplanned failures that require more repairs** (*i.e.*, replacing entire modules rather than individual components), higher labour costs, and greater logistical issues (*i.e.*, shipments of spare parts). Over time, this degrades readiness and increases life-cycle expenses beyond original projections[46]. As such, low-cost designs should focus on **efficiency across the entire system**, rather than limiting funding in ways that **increase vulnerability** or **lead to premature failures**. In some cases, modular designs may provide a **better cost-effective alternative** than reducing individual component replacements, as they allow for **more strategic upgrades** without compromising performance. A well-executed low-cost strategy should **enhance affordability while preserving reliability and adaptability** rather than simply minimising initial expenditures. This does not illustrate a failure of low-cost solutions themselves but rather **how certain cost-saving choices can lead to poor sustainment planning**. Instead of reducing long-term costs, **cutting sustainment budgets** resulted in **higher lifecycle expenses** and degraded operational effectiveness.

Supply chain vulnerabilities and dependencies

Beyond specific platforms, low-cost strategies often leverage **Commercial Off-The-Shelves** (COTS) components from supply chains. As explained in the first section of our paper, this strategy benefits from commercial economies of scale. For example, in its 2015 Strategic Defence and Security Review, the UK's Ministry of Defence advocated extensive use of COTS electronics in land vehicles and shipborne systems to reduce R&D expenses[47]. However, as highlighted in an article by Richardson[48], the issue is linked to the lack of continuity in manufacturing. **The absence of long-term availability for COTS components creates vulnerabilities in defence systems, as they become reliant on parts that may be discontinued, forcing expensive and time-consuming redesigns[49]**. Such deferred redesign costs illustrate how **low-cost can also externalise risk**.

The impact on end-users: Operational effectiveness and capability gaps

If used alone, low-cost design imperatives show the limits of affordability and performance, which ultimately affect end users through **diminished operational effectiveness and**

[46] GAO (U.S. Government Accountability Office). 2012. *Defense Acquisitions: Improved Oversight Could Help DOD Better Achieve Savings from COTS.* GAO-12-108.
[47] HM Government. 2015. *National Security Strategy and Strategic Defence and Security Review 2015: A Secure and Prosperous United Kingdom.*
[48] Richardson, M. 2021. "Using COTS: Is It Worth the Risk?" *Aerospace Manufacturing.* Link.
[49] North Atlantic Treaty Organization, Research and Technology Organization. 2001. *Strategies to Mitigate Obsolescence in Defense Systems Using Commercial Components*, p. 17.

emergent capability gaps. Low-cost design processes tend to, for example, prioritise component substitution or simplified subsystems to meet budgetary thresholds[50]. This can leave front-line operators with systems unable to perform against evolving threat environments; what scholars call "**requirements erosion**"[51]. Consequently, forces may face capability gaps that cannot be mitigated without important upgrades. This situation, in turn, negates initial cost savings.

In addition, **the "perception of low-cost" constitutes a major barrier** to adopting low-cost solutions. Even when a technology can meet military requirements with a low-cost system, **beliefs about quality, reliability, and security are often more important** than "cost-benefit analyses". First, there is a widespread assumption in defence circles that lower price automatically signals lower quality or shorter system lifespan. Purchasers (both policymakers and end-users) often fear that **a cheaper subsystem will fail under combat conditions**, which could expose troops to risk. Second, economically, major primes have historically built their business models on highly specialised subsystems. Introducing low-cost solutions for military capabilities can threaten defence primes who favour high-cost and high-end solutions.

Standards and regulations

The application of European or international **military standards and civilian regulations rarely reduces development and production costs** for European weapon systems[52]. Instead, they often generate **additional requirements and extra costs** that can disadvantage defence industries and prevent them from developing low-cost solutions for military capabilities. Within NATO, complying with STANAGs[53] can sometimes lead to increased development costs and higher prices for European armaments. For instance, in the naval domain, STANAGs for torpedoes have led to larger torpedo dimensions, increasing integration costs on French naval platforms. In the munitions field, certain STANAGs mandate a high number of firing tests, which significantly inflate development costs. In aeronautics for example, certification involves verifying that a new aircraft and its main components meet regulatory airworthiness requirements[54]. This certification process often requires a significant budget that a small or medium-sized enterprise cannot usually bear alone. Moreover, the U.S. FAA[55] and European

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[50] Sköns, E. 2014. "Balancing Cost and Capability: The European Defence Dilemma." *Contemporary Security Policy.*
[51] Thurner, E. 2015. "Why Cheap Can Be Expensive: Requirements Erosion in NATO Programmes." *Policy Brief*, NATO Defense College, No. 26.
[52] Jaouen, A. 2023, p. 56.
[53] STANAGs stands for 'STANdardization Agreements', established by NATO to ensure the interoperability of procedures and equipment, notably weapon systems, among the member countries of the Atlantic Alliance.
[54] Jaouen, A. 2023, p. 56.
[55] FAA stands for the United States Federal Aviation Administration.

EASA[56] impose very high airworthiness requirements, driving up the cost of onboard equipment produced by defence manufacturers. This level of certification expertise is only mastered by a few countries worldwide. As a result, Russian and Chinese military helicopters can be priced more competitively than Airbus helicopters on non-European markets that do not demand FAA or EASA certification. In France, the Direction générale de l'armement (DGA) has recognized these burdens across all defence sectors. **Under its 2022 "Impulsion" transformation plan, it has actively pursued regulatory simplification.** Measures include reducing unnecessary standards (such as eliminating rear radars on armoured vehicles), easing dual civil-military drone qualifications, and streamlining quality-control procedures[57].

RECOMMENDATIONS: INTEGRATING LOW-COST SOLUTIONS FOR MILITARY CAPABILITIES

The end-goal of this report has been to examine how Western defence industries can meaningfully **integrate low-cost solutions for military capabilities as a result of strategic choice**. As predicted by Norman Augustine, in the context of rising competition, costs, and evolving technology, it cannot be sustainable for modern militaries to invest exclusively in high-end systems. By contrast, as shown in this report, relying solely on low-cost solutions is not sustainable either. Instead, a balanced approach is required. To achieve this, four fundamental axes must be studied: **strategy**, **domain**, **technology**, and **techniques**.

What strategy? Low-cost as a strategic enabler rather than a compromise

Low-cost systems should be adopted when they are operationally efficient, not just because they are cheaper. Thus, **the most effective force structures are those that combine the high-end and low-end technologies.** Recent analyses of the Ukraine conflict highlight how advanced Western missile systems operate in concert with masses of locally produced munitions[58]. In sum, **the low-cost approach should be viewed not as a substitute for quality, but as a complementary tool**. To this end, the following principles should be kept in mind:

1. Quantity with purpose.
2. Selective deployment.
3. Preserving high-end edge.

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[56] EASA stands for European Union Aviation Safety Agency.

[57] Chiva, E. 2022. "Comme toute chose vivante, la DGA doit se transformer". In *Esprit Défense*, no. 5. Ministère des Armées. Link.

[58] Slusher, M. 2025. *Lessons from the Ukraine Conflict: Modern Warfare in the Age of Autonomy, Information, and Resilience*. Washington, DC: Center for Strategic and International Studies (CSIS). Link

In addition, **adopting low-cost responses for low-cost menace is essential to ensure strategic proportionality**. The use of Iranian drones by Russia has rendered this asymmetry especially visible. Indeed, relying on *Aster-30* missiles against *Shahed-136* in unsustainable, especially economically. An analysis by the CSIS upholds this argument[59] and explains that, from September 2022 to December 2024, Russia launched over 14,700 one-way attack drones at Ukrainian targets. While these drones hit their targets less than 10 % of the time, their affordability allowed Russia to fire hundreds of them daily. Ukraine had to deploy high-cost countermeasures, including surface-to-air missiles and electronic warfare systems, which were far more expensive per unit than the drones themselves. Western forces must, therefore, **develop low-cost systems designed specifically to counter low-cost threats**.

Lastly, **low-cost capabilities offer an economical advantage in the context of an "economy of war" framework**. This would indeed help reduce financial and logistical pressure, and the risk of losing expensive capabilities. In this sense, low-cost, when deliberately integrated, becomes a strategic enabler rather than a compromise.

What domains? A selective integration of low-cost based on operational relevance

The low-cost strategy cannot be applied across all domains. There should be a targeted approach identifying **where** low-cost solutions are **both technically feasible and operationally appropriate**. As explained before, where systems can be conceived, designed or constructed in a modular way, but also mass-produced, and based on reliable commercial technologies, low-cost strategies can offer benefits.

- **Tactical UAVs and loitering munitions**[60]**, for instance, offer high potential**. These platforms can often be developed using commercially available components, use fast prototyping cycles, and be produced in large volumes at a low cost[61]. The same logic applies to **ground munitions and artillery**, where production is based on modularity or propulsion systems, and when the supply chains are stable.

- However, **Electronic Warfare (EW) systems and Uncrewed Ground Vehicles (UGVs) present a moderate potential for low-cost** as they usually depend on complex software architectures and autonomous algorithms. These features often lead to longer development times or higher lifecycle costs.

[59] Hollenbeck, N., Altaf, M. H., Avila, F., Ramirez, J., Sharma, A., & Jensen, B. (2025). *Calculating the cost-effectiveness of Russia's drone strikes*. Center for Strategic and International Studies. Link

[60] For example, the French Air and Space Force is evaluating the use of guided and unguided rockets as a cost-effective counter-unmanned aircraft system (C-UAS) solution for its Dassault Rafale combat aircraft. Link

[61] Army Technology. 2021. "Loitering Munitions: Technology Trends." *Army Technology*. Link.

- Finally, **jet-powered UAVs, precision-guided missile systems, and advanced air defence networks present limited and low prospects for low-cost**. They are usually built on expensive technologies.· Thus, forcing a low-cost logic does not necessarily make sense.

Therefore, **not all military domains are suitable for a low-cost approach**, which means that assessing the **entire production chain** is necessary to identify specific domains. Below is a simplified framework to evaluate low-cost suitability:

Table 3 – Low-cost potential: Domain specialisation

Domain	Low-cost potential	Key constraints
Tactical UAVs / Loitering munitions	High	Dependence on microelectronics and navigation components
Artillery and Ground munitions	High	Easier to mass-produce with stable supply chains
Electronic Warfare (EW)	Moderate	Requires sophisticated software and signal processing
Ground Vehicles (UGVs)	Moderate	Battery tech, terrain resilience, and autonomy limitations
Jet-powered UAVs / Missiles	Low	Requires turbofans, advanced aerodynamics, and guidance tech
Air defence systems	Low	Precision, reliability, and survivability requirements

Source: IRIS

What technologies? Retrofit and dual-use?

The integration of **retrofit technologies** (upgrading older platforms with modern subsystems) can be a low-cost strategy. However, retrofitting can also lead to maintenance and deferred costs, reduced availability, and ethical concerns. Thus, there must be a careful evaluation of the lifecycle costs, maintenance, and context to adopt such a strategy.

In addition, **dual-use technologies** can be essential to low-cost military systems. They are not only cheaper but also more rapidly developed. Yet, as shown in this report, they also raise strategic concerns around export control and supply chain security. Therefore, incorporating dual-use technologies requires a broader "**anticipation of technological variability"**[62] over

[62] Center for a New American Security. 2023. *Dual Use Technology and U.S. Export Controls.* CNAS Technology Policy Lab. Link

time. Therefore, any low-cost programme must **anticipate technological variability** and **design systems with component flexibility in mind**.

What techniques? Engineering solutions, flexible regulations, and export markets

- **MOSA and MBSE**

As explained, **modularity enables the integration of low-cost sub-assemblies into larger "plug-and-play" weapon or platform families**, which reduces development risk, simplifies upgrades, and allows insertion of emerging low-cost technologies without requiring the whole system redesign. As highlighted in Hérault's thesis[63], a core enabler of this modular architecture lies in the early phases of conception and design. According to Hérault, the way a system is initially conceived has a decisive impact on the feasibility of future modular upgrades and internationalised production. **Designing for modularity from the outset facilitates parallel development paths**, simplifies system integration, and improves compatibility across variants and configurations. Moreover, **modular design allows production activities to be geographically dispersed while maintaining coherence in the final assembly**. This flexibility supports industrial collaboration and offsets agreements, while reducing dependency on a single supply source.

Therefore, in each capability block of major programmes, **integrating at least one "low-cost insert"[64] would drive down cost without redesigning the whole weapon**. Moreover, **defence industries should establish modular design standards and open interface protocols across platforms and suppliers**. This would enable greater interoperability, while facilitating lifecycle upgrades with minimal disruption. Industrial actors should also invest in Model-Based Systems Engineering (MBSE) to simulate modular architectures. Together, MOSA and MBSE provide a powerful framework for aligning defence design with the **economic logic of modularity**.

- **Regulatory flexibility for UAVs**

Current standards and norms impose certification requirements that dramatically raise the cost of UAVs. Interestingly enough, the U.S. Air Force programmes – which a lot operate in almost unpopulated theaters – have **relaxed certain requirements for some missions**. This can cut costs by 30-50 % without compromising safety[65]. However, French military UAVs, for instance, are frequently deployed overpopulated areas. Thus, safety relaxations must be adapted where possible. This means that any proposal to reduce certification burdens should

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[63] Hérault, P. 2021, pp. 244–275.
[64] Ibid.
[65] GAO (U.S. Government Accountability Office). 2019. *Unmanned Aircraft System Certification: Observations on Drone Integration into National Airspace.* GAO-19-618.

distinguish between different UAV categories[66]. A practical recommendation would be to adopt a differentiated regulatory framework: low-cost UAVs used for Intelligence, Surveillance, and Reconnaissance (ISR) in low-risk or unpopulated areas could follow **a "light" certification track, similar to the ones already applied in the civilian sector**. This would help reduce costs without compromising public safety or breaching established norms.

- **Leveraging export markets for UAVs**

As for exporting low-cost systems, like UAVs, it raises concerns about **dual-use proliferation and potential misuse by non-state actors**. Reinforcing export control regimes is thus crucial to ensure that low-cost arms sales do not undermine regional stability. A central issue is that the **low-cost defence model increasingly relies on dual-use components**: commercially available technologies like GPS modules, microprocessors, and communication systems originally designed for civilian use. It is therefore essential to **distinguish between two related but separate concerns**. First, whether complete UAVs fall under dual-use regulations; and second, the broader trend of low-cost systems being built on a foundation of dual-use technologies. The **strategic risk lies not only in what is exported, but in how easily military capabilities can be assembled using components with civilian origins**. Importantly, it should be noted that not all UAVs are regulated as dual-use items[67]. This creates a regulatory gap that is increasingly exploited in low-cost defence production. To mitigate these risks, strengthening control regimes should not focus solely on complete weapon systems, but also on **tracking and regulating high-risk subcomponents**. In short, **managing the dual-use challenge is central to ensuring that low-cost military exports do not come at the expense of regional and global stability**.

[66] European Union Aviation Safety Agency (EASA). n.d. "Open Category — Low Risk — Civil Drones." *EASA*. Link.
[67] Wassenaar Arrangement. 2023. *List of Dual-Use Goods and Technologies and Munitions List.* Link.

CONCLUSION

The low-cost model offers promising opportunities for reshaping defence capabilities, but it cannot be applied universally across all domains. As demonstrated throughout this report, low-cost solutions are not simply about spending less, they represent a fundamentally different design and production logic. **The primary objective, therefore, is not to replace high-end technologies with cheaper alternatives, but to complement them strategically**. To do so, industry must **identify domains along the value chain** where low-cost solutions can be effectively implemented, for instance drones and munitions. This requires **prioritising specific techniques** – such as Modular Open Systems Architecture (MOSA) – and leveraging technologies that are truly low-cost, not merely low-tech. Ultimately, such strategies imply the need for a **broader paradigm shift** in how military value is assessed. The adoption of low-cost by strategic choice requires **institutional flexibility**. Defence industries must build cultures that tolerate experimentation, accept incremental performance gains, and prioritise affordability when it serves the operational aim.

ANNEX : LOW-COST TECHNOLOGIES FOR MISSILES AND UAVS

Technology	Estimated cost	Potential uses
Electromagnetic railguns	$20,000–$100,000 per projectile	Long-range precision strikes, lower explosive dependency
Laser weapons	<$1 per shot	Anti-drone systems, missile interception, force protection
Surveillance radar	Reduced cost via 30% savings in size/weight/power	Airborne surveillance for compact platforms
Digital simulation	Low (via consumer software like DCS World)	Combat training, missile targeting practice
Specialised imaging	Low (civilian tech adaptation)	Aerial reconnaissance, low-cost ISR
Blockchain	Low (open-source base)	Fleet management, data integrity, secure records
AI and Big Data	Reduced R&D and ops cost	Predictive maintenance, digital twins for aircraft
Quantum sensors	Lower cost with miniaturisation efforts	Precision navigation, detection applications
Turbogenerators for aircraft	Lower operating cost	Electric propulsion for UAVs and light aircraft
CERBERE tethered balloon	Much cheaper than drones or planes	Persistent aerial surveillance (ROEM)
Border surveillance aerostats	Lower cost via passive surveillance	European border monitoring
Additive Manufacturing (AM)	Cost savings on complex, non-critical parts	On-demand repair/parts in field, inventory reduction
Nanotech for soldiers	Development phase	Enhanced gear (lighter, denser power systems) for infantry and aerospace

Source: IRIS, based on: Jaouen, A. 2023. *Le modèle low-cost : propositions pour la défense*. Ministère des Armées, Conseil Général de l'Armement*, pp. 70-72.*

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