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Innovation is not enough: the three valleys between technology and European military capability

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Abstract:

Europe has expanded its defence innovation and industrial cooperation instruments, yet still struggles to convert technology into military capability. This paper identifies three valleys: from research to product, from product to industrial scale, and from procurement to capability. The third is distinctly military: purchasing a system is not enough unless all the DOTMLPF-I components needed to employ, sustain and adapt it are fully integrated. Institutional fragmentation, procurement delays and weak demand aggregation deepen these discontinuities. Spain illustrates the paradox: it participates actively in European defence innovation but must still shorten the chain from operational need and experimentation to contracting, integration and fielding.

Keywords:

Military innovation; defence industry; procurement; European Union; Spain.

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Introduction

Europe has learned how to fund projects and prototypes, but it still struggles to turn demonstrators into systems that enter service. A company may develop a promising solution, secure public funding, build a demonstrator and test it during an exercise. None of this guarantees that the system will reach a unit. Technology does not necessarily fail; more often, it ages in the bureaucracy, caught between a requirement that is never formalised, a budget that never appears and a buyer unwilling to assume the risk. By the time the institution reaches a decision, the threat has already changed.

This is not an exceptional journey. Europe has universities, technology centres, established companies, new entrants, collaborative programmes and an expanding range of defence-financing instruments. European states have also increased defence spending, strengthened industrial cooperation and begun to remove long-standing barriers that limited access for small firms and private capital. Even so, a considerable gap remains between researching, developing and procuring a system and fielding a usable capability. An innovation may be technically sound, politically prioritised and industrially viable, yet still be lost in the institutional transition.

In 2021, Christian Villanueva asked what capabilities the Spanish defence industry should provide for conflicts in which legacy platforms, widely diffused technologies and still-emerging developments would coexist[1]. Five years later, the question remains valid, but the context requires it to be broadened. The war in Ukraine and Europe's new industrial cycle require us to ask not only what should be developed, but also what conditions allow those developments to become procured, integrated, sustainable and adaptable systems before they lose relevance.

Recent work on adaptive latency has focused on the time an organisation needs to identify a problem, develop a response and introduce it before the adversary neutralises its advantage[2]. This article addresses another part of the same process: why an

[1] VILLANUEVA, Christian. “La industria española de defensa ante los nuevos conflictos: capacidades a aportar”, *Revista de Estudios en Seguridad Internacional*, vol. 7, no. 2, 2021, pp. 63-81.

[2] COLOM-PIELLA, Guillem. “Más rápido que la contramedida: Aceleración, latencia adaptativa y transformación militar en la guerra de Ucrania”, *Ejércitos*, 16 july 2026. Available at: https://www.revistaejercitos.com/articulos/mas-rapido-que-la-contramedida-aceleracion-latencia-adaptativa-y-transformacion-militar-en-la-guerra-de-ucrania/

innovation that has been funded, tested and even procured may still fail to become a fielded capability.

Europe continues to suffer from familiar weaknesses in military innovation: insufficient investment, fragmented markets, duplication, technological dependencies and less scale than the United States or China. This paper focuses on another, less visible problem: even when the technology exists, converting it into a fielded capability can prove difficult. It analyses that difficulty through three valleys: from research to product, from product to scale, and from procurement to capability. The third is distinctly military, because it begins after the equipment has been procured but before all the components required to employ it, sustain it and generate a military effect have been completed and integrated.

Acceleration, technological overtaking and industrial change

For much of the industrial age, defence ministries were the dominant customers for technologies with few civilian-market equivalents. The state defined requirements, funded development, absorbed risk and maintained long-term relationships with a limited number of contractors. This model fostered the rise of large integrators able to combine complex subsystems, certify platforms and sustain them for decades. It also produced increasingly expensive programmes, long development cycles and high barriers to entry.

That balance has shifted. Advances in computing, artificial intelligence, communications, microelectronics, software, robotics and space services are now driven primarily by civilian markets. Bellais and Fiott noted years ago that commercial innovation was lowering some barriers to entry and forcing both traditional firms and military organisations to change how they absorb technology[3]. Villanueva uses the term *sorpasso* to describe the shift of the technological engine from the defence industry towards large civilian companies – especially American ones – that control the infrastructure, talent, data, cloud services, chips and models underpinning future warfare[4].

This shift does not make traditional defence contractors redundant. An application, sensor or algorithm may originate outside the sector, but turning it into military capability

[3] BELLAIS, Renaud and FIOTT, Daniel. “The European Defense Market: Disruptive Innovation and Market Destabilization”, *The Economics of Peace and Security Journal*, vol. 12, no. 1, 2017, pp. 37-45.

[4] VILLANUEVA, Christian. *Hacia la última guerra. Teoría estratégica, aceleración tecnológica e hipercomplejidad.* Ejércitos, 2026.

still requires security, certification, integration, production, sustainment and contractual accountability. New entrants provide speed and specialisation; integrators provide architecture, access to the customer and the capacity to produce at scale. The choice is not between the two. The task is to prevent procedures designed for complex platforms from excluding new actors, while ensuring that the rapid incorporation of new solutions does not leave forces with incompatible, closed or unsustainable systems[5].

Technological acceleration intensifies this tension. In Villanueva's framework, more information generates greater complexity; micro-innovations accumulate; periods of stability shorten; and the boundary between incremental change and systemic transformation becomes less distinct. Industry and government, however, do not move at the same pace. Software may be updated in weeks, a production line may take years to expand, and a major platform may remain in service for decades. Military innovation therefore no longer follows a single rhythm, but combines heterogeneous cycles[6].

Europe cannot respond by forcing every technology to move at the pace of the slowest, nor by treating every system as a commercial product. It must manage several speeds. Crewed platforms, critical infrastructure and systems whose failure would have grave consequences require extensive testing and stable contracts. Software, selected sensors, electronic components, expendable systems and some artificial-intelligence applications require short production runs, continuous experimentation and configurations able to evolve over time. The challenge is to integrate them within a common architecture.

The three valleys of military innovation

The expression “valley of death” usually describes the stage at which a promising technology cannot secure enough funding to move from laboratory to market. In defence, the metaphor is incomplete. A product may cross the technological and commercial valley

[5] VILLANUEVA, Christian. “Futuro de la industria de defensa en España ante las transformaciones en Europa y Estados Unidos”, *Estrategia podcast* no. 128, 27 January 2025. Available at: https://global-strategy.org/futuro-industria-defensa-espana.

[6] VILLANUEVA, *Hacia la última* Guerra. Especially the chapters on information, complexity, punctuated equilibrium, acceleration, protean organisations and new military planning.

but fail to reach the required scale. It may even be procured without becoming military capability. Three discontinuities must therefore be distinguished.

The first valley separates an interesting technology from a product able to meet a military requirement. This is where the familiar problems are concentrated: insufficient technical maturity, lack of capital, certification difficulties, limited knowledge of the user or the absence of a clearly articulated demand. A solution may look attractive in a funding call and fail when exposed to electronic interference, adverse weather, security constraints, poor maintenance or integration with legacy networks.

Europe has multiplied the instruments available to fund, accelerate and test technologies. The European Defence Fund supports collaborative research and development, while the European Commission, the European Defence Agency and NATO operate initiatives intended to connect firms, users and test centres. They do not, however, form a single chain. The Commission works through budgets, market regulation and industrial policy; the European Defence Agency through intergovernmental cooperation; and NATO through Allied requirements and interoperability. Möhring has shown that these initiatives reflect supranational, intergovernmental and transatlantic approaches that may complement, overlap with or compete against one another[7].

The proliferation of instruments creates more opportunities, but can also scatter innovators across different calls, users and criteria. The problem arises when a project is designed to win funding rather than solve an operational need. Administrative success may then precede military failure.

The European Commission has begun to recognise this gap. The Defence Industry Transformation Roadmap identifies barriers to accessing users, contracts and growth finance, and seeks to accelerate the passage from technology to market. AGILE, politically agreed in July 2026 and due to begin in 2027, is intended to develop, test and deploy solutions within weeks or months through challenges defined with member states. Experimentation thus ceases to be a generic activity and becomes tied to concrete

[7] MÖHRING, Johanna. *EUDIS, HEDI, DIANA: What's behind Three Defense Innovation Acronyms?* IFRI, 25 September 2024. Available at: https://www.ifri.org/en/memos/eudis-hedi-diana-whats-behind-three-defense-innovation-acronyms

problems. Its success will nevertheless depend on whether a contracting route exists after the trial[8].

The second valley appears when a viable product exists, but the company lacks the capacity to manufacture it, finance its growth or sustain sufficient demand. Many firms can produce dozens of units; few can deliver thousands while maintaining quality, securing component supplies and meeting security requirements. Without predictable orders, investment in production lines, staff and inventories is risky. Without industrial capacity, the buyer doubts that delivery is feasible. The company is caught between the absence of a contract and the inability to expand output without one.

The war in Ukraine has returned production to the centre of strategy. Quality still matters, but a solution that cannot be replaced, repaired or modified at the rate of battlefield consumption has limited value. This does not mean that every capability must be mass-produced. It means that volume, supply-chain resilience and delivery time are part of military effectiveness.

NATO has placed this difficulty at the centre of its agenda. The 2025 Rapid Adoption Action Plan established a benchmark of identifying, testing and adopting new technological products, generally within no more than twenty-four months. The scale-up package approved in Ankara in 2026 added three elements: an aggregated demand signal, the mobilisation of private capital and a manufacturing network – the NATO Engine – designed to connect firms with factories and flexible production capacity[9]. Without credible demand, finance and manufacturing capacity, innovation remains a demonstrator[10].

The European Investment Bank has also expanded the capital available to security and defence firms, including through specific operations in Spain. These measures ease

[8] EUROPEAN COMMISSION. *EU Defence Industry Transformation Roadmap*, 19 November 2025; and *Programme for Agile and Rapid Defence Innovation*, political agreement of 15 July 2026. Available at: https://defence-industry-space.ec.europa.eu/eu-defence-industry/programme-agile-and-rapid-defence-innovation_en

[9] NATO. *Summary of NATO's Rapid Adoption Action Plan*, 25 June 2025. Available at: https://www.nato.int/en/about-us/official-texts-and-resources/official-texts/2025/06/25/summary-of-natos-rapid-adoption-action-plan

[10] NATO. *NATO Innovation Scale-Up Package*, 8 July 2026. Available at: https://www.nato.int/en/about-us/official-texts-and-resources/official-texts/2026/07/08/nato-innovation-scale-up-package

the financial constraint, but they cannot replace the decisive signal: a customer willing to place an order[11].

This creates a difficult tension. Industry needs stable demand in order to invest; armed forces need the freedom to modify technology that may change rapidly. Contracts that are too short prevent production from scaling. Contracts that are too rigid freeze the configuration. One possible answer is to commit to volume without fixing every component: product families, successive batches, interface standards, upgrade rights and competition at subsystem level. Scale should stabilise production without locking the solution.

The third valley is the least visible and the most distinctly military. A system may have been developed, certified, delivered and procured without constituting a capability. Delivery marks the end of the industrial contract, but not necessarily effective entry into service. The remaining components required to employ, sustain and adapt the system must still be completed and integrated.

A military capability is not a system. In NATO capability development, it is the ability to create an effect through the employment of an integrated set of doctrine, organisation, training, materiel, leadership development, personnel, facilities and interoperability – DOTMLPF-I. Procurement covers, at most, the "M". Without the other components, there is equipment in the inventory, not capability[12].

Innovation policies tend to measure inputs and intermediate outputs: funding mobilised, participating firms, patents, prototypes, trials or contracts. These are useful indicators, but they do not answer the decisive question: how many military units can employ the solution, under what conditions and with what sustainment? The third valley begins precisely where much industrial policy ends.

Hypercomplexity reinforces the problem. Every additional system introduces dependencies, interfaces and information demands. A sensor may improve observation

[11] EUROPEAN INVESTMENT BANK. *EIB Group Powers Up Flagship Investment Instruments to Boost Europe's Tech Leadership and Defence Capabilities*, 25 March 2026. Available at: https://www.eib.org/en/press/all/2026-113-eib-group-powers-up-flagship-investment-instruments-to-boost-europe-s-tech-leadership-and-defence-capabilities

[12] COLOM PIELLA, Guillem. "Fuerza futura, decisiones presentes: el planeamiento de la defensa como política pública", *Documento de Opinión IEEE* 24/2026, 2 March 2026. Available at: https://www.defensa.gob.es/ceseden/-/ieee/2026-planeamiento-defensa-politica-publica

while simultaneously increasing signature, data traffic and cognitive load. A drone may extend a unit's reach while multiplying batteries, frequencies, applications, training requirements and sustainment burdens. A local advantage can become systemic friction. Hence Villanueva's emphasis on open architectures and organisations able to reconfigure without losing coherence[13].

This framework distinguishes three outcomes that are often conflated. A technology opens a possibility; a product offers a reproducible solution; a capability integrates its DOTMLPF-I components to generate a military effect. Innovation completes its journey only when it reaches this final level.

European cooperation can help close these valleys by aggregating demand, lengthening production runs and defining common standards. But it cannot replace national governments as buyers or armed forces as users. Every project should begin with an identified operational need, a route to experimentation, a designated contracting authority and a plan for expanding production[14]. Without that continuity, cooperation may generate consortia, funding and demonstrators without producing fielded capabilities.

Ukraine as a mirror, not a template

Ukraine's growing integration into the European ecosystem offers an exceptional opportunity to narrow the gap between technology and operational experience. *BraveTech EU* combines solution selection, testing under realistic conditions and assessment by European and Ukrainian experts. In July 2026, the European Defence Agency began working with the first group of selected companies to test uncrewed systems, resilient communications and munitions against scenarios derived from the conflict. The model's value lies in moving testing away from controlled demonstrations and closer to the conditions most likely to degrade the system[15].

[13] VILLANUEVA. *Hacia la última guerra*.

[14] EUROPEAN COMMISSION. *European Defence Industrial Strategy*, 5 March 2024. Available at: https://defence-industry-space.ec.europa.eu/eu-defence-industry/edis-our-common-defence-industrial-strategy_en; and *Readiness Roadmap 2030*, 16 October 2025. Available at: https://defence-industry-space.ec.europa.eu/eu-defence-industry/readiness-roadmap-2030_en

[15] EUROPEAN DEFENCE AGENCY. *EDA Will Work with the First Group of Innovators under BraveTech EU Phase II*, 14 July 2026. Available at: https://eda.europa.eu/news-and-events/news/2026/07/14/eda-starts-working-with-the-first-group-of-innovators-under-bravetech-eu-phase-ii

Ukraine offers something Europe can scarcely reproduce in peacetime: users under constant pressure, immediate operational problems and rapid cycles of testing and modification. Europe brings laboratories, certification, capital, industrial capacity and access to larger markets. The complementarity is obvious. So are the risks. A solution suited to a Ukrainian brigade may not meet European security, interoperability or sustainment requirements. Technology designed for rapid battlefield consumption may not integrate into Allied networks. And a company adapted to wartime demand may struggle to survive ordinary budget cycles.

Ukraine's experience helps identify where European procedures add value and where they introduce delay without reducing risk. Not everything should be accelerated in the same way. Operational testing can be compressed; certification of a crewed platform cannot. A small batch of expendable systems can tolerate greater uncertainty; integration into a command network requires stronger assurance. The lesson is not to reproduce a wartime economy, but to build reversible peacetime mechanisms that allow learning before commitments are made at scale.

Cooperation with Ukraine will have genuinely transformative value only if its results cross all three valleys. Selecting and testing technologies is merely the beginning. There must be national buyers, finance for larger-scale production, integrators able to connect the systems and units willing to change their procedures. Otherwise, Europe will import lessons from the front and turn them into another catalogue of demonstrators.

Spain: high participation, uncertain conversion

Spain participates actively, but we still know little about how many of those projects ultimately become fielded capabilities. Its industrial base has strengths in naval and air platforms, electronics, space, command and control, simulation, missiles, vehicles, drones and digital technologies. Villanueva's 2021 article argued for identifying realistic capabilities and niches in which Spanish industry could add value, rather than attempting to master every technology[16].

[16] VILLANUEVA, “La industria española de defensa”.

Spain's presence in the European Defence Fund confirms its ability to join consortia and compete for projects. Fiott counted 291 instances of participation by Spanish entities in the 2021-2023 calls, placing Spain among the Fund's most active member states[17]. This performance demonstrates industrial and technological depth and a prominent role in consortia, but participation and industrial returns do not guarantee that the resulting systems will find a national buyer, a user unit or a route into the force. The relevant metric is not only how many entities participate, but how many projects complete the full sequence: demonstration, contract, integration, fielding and upgrading.

Spanish scholarship had already identified part of the problem. Martí Sempere argued that defence innovation requires needs and technologies to co-evolve, and that traditional contracts may be too rigid for programmes exposed to uncertainty, revision and failure[18]. More recently, an Elcano study described the Spanish ecosystem as fragmented and organised in silos, with still-limited links among defence, civilian innovation, start-ups, universities, technology centres and public buyers[19].

Spain has responded. The 2025 Industrial and Technological Plan for Security and Defence mobilised an initial investment of €10.47Bn and opened new programmes for modernisation, dual-use technologies and industrial reinforcement[20]. The 2026 Defence Technology and Innovation Strategy explicitly recognises technological acceleration, promotes open and dual-use innovation, and calls for modernising planning, contracting, evaluation, experimentation and engagement with the Defence Technological and

[17] FIOTT, Daniel. "¿Un socio de elección? El desempeño de España en el Fondo Europeo de Defensa en 2023", *Real Instituto Elcano*, 3 July 2024. Available at: https://www.realinstitutoelcano.org/analisis/un-socio-de-eleccion-el-desempeno-de-espana-en-el-fondo-europeo-de-defensa-en-2023. For a broader discussion of Spanish participation in European defence-cooperation frameworks, see CÓZAR MURILLO, Beatriz. *The Permanent Structured Cooperation (PESCO) of the European Union: Means, Ways, Ends and Tempo*. Ejércitos, 2025.

[18] MARTÍ SEMPERE, Carlos. *Defence Innovation: New Models and Procurement Implications. The Spanish Case*. Paris, IRIS/ARES Group, September 2020. Available at: https://www.iris-france.org/149317-defence-innovation-new-models-and-procurement-implications-the-spanish-case

[19] ARTEAGA, Félix; FIOTT, Daniel and SIMÓN, Luís. *The Defence Dilemma: Can Spain Ride Europe's Defence Revival?* Real Instituto Elcano, 2025. Available at: https://www.realinstitutoelcano.org/en/policy-paper/the-defence-dilemma-can-spain-ride-europes-defence-revival

[20] GOVERNMENT OF SPAIN. *Plan Industrial y Tecnológico para la Seguridad y la Defensa. Gobierno de España.* Available at: https://www.lamoncloa.gob.es/consejodeministros/resumenes/Documents/2025/230425-plan-industrial-y-tecnologico-para-la-seguridad-y-la-defensa.pdf

Industrial Base[21]. The official diagnosis is therefore moving closer to the conversion problem.

The result may be a form of accelerated continuity: more authorisations, contracts and programmes without a commensurate increase in near-term availability[22]. In terms of the framework proposed here, this effort may help close the second valley – by providing finance, demand and scale – without necessarily closing the third, where DOTMLPF-I integration must still be completed before an effective capability exists.

The risk is that the new effort reproduces a preference for major programmes and industrial returns without creating an equivalent route for fast-cycle technologies. Spain's Special Modernisation Programmes (*Programas Especiales de Modernización* – PEM) provide stability, volume and integration capacity, but they are designed for complex systems and long time horizons. They cannot become the only gateway to modernisation. If a software component, sensor, expendable drone or artificial-intelligence tool must wait for the full cycle of a major programme, it will arrive too late or be absorbed into a closed architecture.

Spain needs to preserve its prime integrators because they are essential to turn subsystems into capabilities, sustain platforms and participate in European programmes. But it should require open interfaces, access to data, competition among component suppliers and mechanisms for bringing in new providers. Strategic autonomy is not about manufacturing every part; it is about retaining sufficient freedom to maintain, modify and connect critical systems.

From projects to capability

The three valleys will not be crossed by creating another fund or adding another accelerator. They are crossed by assigning responsibility for each transition. There is no military innovation without a user, no scale without demand and no capability without integration. Four measures can translate this logic into practice.

[21] MINISTRY OF DEFENCE. *Estrategia de Tecnología e Innovación para la Defensa 2026*, 2026. Available at: https://tecnologiaeinnovacion.defensa.gob.es/descripcion-de-la-estrategia

[22] COLOM-PIELLA, Guillem. "After the War Begins: Ukraine's Shock and Spain's Accelerated Continuity in Defence Procurement", *Defence and Peace Economics*. https://doi.org/10.1080/10242694.2026.2642698

An accountable user. Every significant initiative should respond to a need articulated by a unit, command or capability authority. The sponsor should not select companies or replace the procurement authority, but should validate the problem, participate in trials and accept the doctrinal and organisational consequences. Without an accountable user, innovation risks becoming technology in search of a mission.

Buy to learn. Spain has R&D programmes, contracting instruments, market consultations and units able to test systems. What it lacks is a stable route for buying limited batches, employing them under realistic conditions, comparing alternatives, introducing modifications and cancelling projects without every trial becoming a permanent programme. Experimental procurement should not bypass controls; it should generate information before resources are committed at scale.

Stabilise volume, not configuration. For fast-moving technologies, contracts should commit to quantities, production capacity or required effects while allowing components and software to evolve within defined interfaces. This requires agreement on technical data rights, access to data, cybersecurity, supplier substitution and update procedures. Architecture becomes more important than the initial configuration.

Measure capability, not activity. Alongside spending, projects and industrial participation, governments should record the time from need to trial, from trial to first purchase and from contract to integration; the number of military units able to employ the solution; sustainable monthly output; the share of replaceable components; and update frequency. Cancelled projects should also be counted. An organisation that never cancels is not necessarily better at choosing; it may simply experiment too little or avoid acknowledging failure.

These measures do not eliminate uncertainty; they distribute it differently. Instead of attempting to remove every risk before procurement, they allow small, reversible and measurable risks to be taken before a decision is locked in. This logic is compatible with security, financial control and public accountability, provided that technologies, costs and consequences are differentiated.

Conclusions

Innovation is not the funding of research, the demonstration of a prototype or the award of a contract. It means turning a technology into a product, producing it at the required scale and integrating it into a force able to employ, sustain and adapt it. Three different valleys open between those stages. The third – between procurement and capability – is the one most easily obscured by industrial statistics.

Spain is well placed to benefit from Europe's new industrial cycle. It has competitive firms, integration capabilities, experience of cooperation and a prominent position in the European Defence Fund. It has also strengthened its strategies and investment. Its real test, however, will not be how many projects it launches, but how quickly it can turn an operational need into a fielded capability.

Technological acceleration does not eliminate major programmes or turn defence into an ordinary commercial market. It requires several speeds to be managed. Long-cycle platforms must coexist with components, software and expendable systems subject to continuous iteration. Those unable to connect the two rhythms will fund innovation, buy technology and still arrive too late.

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