10 TECHS TO WATCH FOR DEFENCE APPLICATIONS

DECEMBER 2025

MARKET TRENDS REPORT

ANALYZING KEY TRENDS FOR INFORMED DECISION-MAKING

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ARTEM-IS
INFORMATION & STRATEGIES

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Introduction

In an era marked by rapid technological advancement and uncertain geopolitical contexts, innovations initially developed for commercial or societal benefits are now being recognized for their potential to enhance national defence capabilities. This convergence operated a shift in which companies not active in military equipment or defence applications can now find opportunities in an evolving and in-need market.

Luxembourg is undergoing a significant transformation in its approach to national security. In response to heightened global tensions and commitments to collective defence frameworks, the Luxembourg government has recently announced wanting to accelerate its initial goal of spending 2% of its Gross National Income (GNI) by 2030. The country is now aiming at achieving this target at the end of the year (2025). This initiative represents a substantial increase from the current allocation of €780 million, aiming to reach approximately €1.18 billion (*Le Quotidien, May 2025*).

This strategic investment underscores Luxembourg's dedication to strengthening its role within NATO and the European Union's defence mechanisms.

This report introduces ten selected contemporary technologies currently mostly utilized in civilian contexts that possess significant potential for immediate or long-term military & defence applications. By examining these technologies, the report aims to provide insights into how Luxembourg can effectively integrate dual-use innovations into its defence strategy, thereby reinforcing its commitment to national and European security.

To ensure a good understanding of the present report, text captions have been added to describe the applications/missions of the technologies studied in the military & defence sector and the strengths/advantages offered by the technologies for the defence sector (*see below*).

Missions Strengths

Key Technologies

Activable on a short-term basis

AUTONOMOUS SYSTEMS

Drones and autonomous vehicles (UAV, UGV)

#1 Reconnaissance missions
#2 Logistical transport in hostile areas
#3 Information gathering on areas of military interest

#1 Decision-making autonomy / AI
#2 Payload and endurance
#3 Resistance to jamming / EW / cyber
#4 Manoeuvrability and fast deployment

Autonomous systems, including **UAVs** (Unmanned autonomous vehicles) and **UGVs** (Unmanned ground vehicles), are extensively used in defence for missions qualified as “dull, dirty and dangerous”.

UAVs were primarily employed for **intelligence, surveillance, and reconnaissance missions**, in difficult-to-access or hostile areas. They can provide real-time data and imagery, enhancing situational awareness and decision-making capabilities. The use of UAV for ‘search and destroy’ missions has grown exponentially since the conflict in Ukraine (‘first person view” / FPV UAV), using AI and optical fiber to enhance effectiveness and resilience facing electronic and cyber warfare.

UGVs are utilized for **ground reconnaissance and logistical transport**, capable of navigating through terrains to deliver supplies or evacuate injured soldiers. Additionally, they can be equipped with **advanced sensors and communication systems** to support complex missions, making them versatile tools in modern defence operations. Armed platforms are heavily tested since Ukraine.

INNOVATIVE MATERIALS AND MANUFACTURING PROCESSES

Additive manufacturing (3D printing)

#1 Rapid production of components in the field
#2 Optimisation of supply chains and stock management

#1 Flexibility of use
#2 Wide range of materials usable
#3 Reduced loss of raw materials and reintegration of recycled materials

Additive manufacturing, or 3D printing, involves creating objects layer by layer from digital models. In defence, it enables **rapid on-site production** of parts, **reducing maintenance delays** and **optimizing supply chains**.

This technology offers flexibility, reduced logistical dependency, and accelerates operational readiness. Challenges include **technological maturity, process standardisation, certification, integration into maintenance systems, and reliability in extreme conditions**. However, artificial intelligence and digital twins’ development offer opportunities for a quicker and more automated production.

Additionally, 3D printing supports circular economy principles by **reducing waste and enabling the recycling of materials**, which can lower the carbon footprint of defence operations.

Key Technologies

Activable on a short-term basis

INNOVATIVE MATERIALS AND MANUFACTURING PROCESSES

Use of advanced materials to improve the strength and weight of equipment

#1 Improving mobility and endurance
#2 Reinforcing ballistic protection
#3 Enhancing stealth

#1 Reduced density of materials
#2 Resistance to compression and heat
#3 Reduced carbon footprint
#4 Low thermal conductivity

Advanced materials and innovative manufacturing processes, such as **advanced ceramics, composites, and ultralight aerogels**, are crucial in defence for enhancing performance, reducing equipment weight, and improving durability and stealth.

These materials are used in **lightweight armor, vehicle and aircraft structures, and aerospace components**, offering advantages like increased mobility, protection, and operational efficiency. Their high resistance to compression provides additional benefits for soldiers, ensuring better protection against impacts and blasts by **eroding or fragmenting projectiles**.

Some obstacles remain, such as high energy consumption in production and environmental regulations due to the use of chemical additives in composites materials' production.

INNOVATIVE MATERIALS AND MANUFACTURING PROCESSES

Smart materials: Shape Memory Polymers (SMPs) and Shape Memory Alloys (SMAs)

#1 Design of lighter, stronger and more adaptable equipment

#1 High deformability and ability to memorise complex shapes
#2 Lightweight of materials
#3 Flexibility of materials

Smart materials, such as Shape Memory Polymers (SMPs) and Shape Memory Alloys (SMAs), react to external stimuli like temperature and pressure by changing their properties or shape, **making them particularly interesting for shock absorption and morphological control systems**, highly beneficial in soldiers' equipment to improve protection, adaptability, and comfort in the field.

In defence, they are used in **aircraft, soldiers' equipment and deployable structures**, such as retractable antennas, foldable solar panels, modular hulls for mobile platforms or drones, flexible exoskeletons.

Their compatibility with 3D printing means that tailor-made components can be produced directly in the field, improving the logistical chains.

Key Technologies

Activable on a short-term basis

ARTIFICIAL INTELLIGENCE

Design and Modelling of Equipment Manufacturing

#1 Transform and optimise traditional design
#2 Improve the speed and accuracy of complex system design, while significantly reducing costs and development times

#1 Optimised designs
#2 Predictive maintenance
#3 Reduced downtime costs
#4 Optimised supply chain management

Artificial intelligence (AI) applied to design and modelling in the defence sector **transforms traditional processes of conception, optimization, and simulation** of defence manufacturers' goods.

By leveraging advanced algorithms like machine learning and deep learning, AI accelerates and improves the design of complex objects, structures and networks, **meeting increasingly demanding technical requirements, while significantly reducing development costs and timelines**.

However, challenges remain, including the need to train models, the fact that data may be biased, the robustness of models and their interoperability with traditional systems. Lack of clear standards on algorithm certification and the increased need for cyber security can also represent challenges.

Key Technologies

Activable on a long-term basis

INTERNET OF THINGS

Biosensors / Health monitoring / Smart textiles – E-Textiles

#1 Optimising soldier performance
#2 Enhancing field operations management
#3 Reinforcing stealth

#1 Real-time monitoring of combatants' vital parameters
#2 Optimisation of soldier comfort
#3 Reduction of soldiers' heat signature

The Internet of Things (IoT) can find applications in defence through **biosensors and smart textiles to monitor soldiers' vital signals and environmental conditions in real-time**, tracking heart rate, respiration and temperature to optimize operational management and prevent health risks. Used in particular by athletes, these technologies can be used to optimise soldiers' performance while improving their comfort.

Less mature technology for the time being, e-textiles focus on developing **advanced textiles with embedded sensors for continuous health monitoring** (internal sensors), but also **environmental analysis** (external sensors) for intelligence operations. Those textiles present obstacles such as resistance to extreme conditions, miniaturised electronic integration, autonomous power supply and data transmission.

ARTIFICIAL INTELLIGENCE

Improved military decision-making through data analysis and collaborative Intelligence

#1 Optimisation of military operations
#2 Improvement of soldier performance through data fusion from all battlefield sensors

#1 Multi-sources information for better situation awareness and targeting
#2 Real-time analysis for accurate decision-making
#3 Enhanced soldier reactivity and safety

Artificial intelligence (AI) in defence enhances decision-making capabilities by **processing, analyzing and exploiting data from multiple sensors on the battlefield**. It can be integrated to specific weapon systems and platforms, to process flows from dedicated sensors (optical, acoustic, etc.) as well as from external sensors (other troops and systems, allied forces, third-party resources including, etc.) in command & control solutions.

This technology improves **situational awareness, battle management, and threat detection**, reducing cognitive load on soldiers and optimizing decision making at all scales.

However, challenges such the miniaturisation of equipment, energy autonomy, real-time management of information flows and user acceptance, can slow down its adoption.

Key Technologies

Activable on a long-term basis

QUANTUM TECHNOLOGIES

Development of secure communication systems resistant to interception or encryption

#1 Development of secure communication guaranteeing confidentiality and integrity
#2 Better anticipate threats for military communication systems

#1 Resistance to "passive listening" attacks through quantum keys
#2 Non-clonability of information
#3 Enhanced resilience of communication systems to interception

Quantum communication technologies leverage quantum mechanics to ensure **secure communication allowing detecting any interception attempt and guaranteeing the confidentiality and integrity of exchanges**.

In the defence sector, these technologies enable **secure military communications, satellite communication, and protected command and control data exchanges.**

However, obstacles such as vulnerability to physical attacks, specialized infrastructure requirements, interoperability between classical and quantum technologies, pose significant challenges.

IMAGERY / SIGNALS / GEOSPATIAL INTELLIGENCE

Satellite surveillance for intelligence and general threat detection

#1 Military intelligence based on satellite imagery and data
#2 Threat detection

#1 High-precision identification and tracking of military targets
#2 Advanced battlefield surveillance
#3 Interception of communications and electromagnetic signals

Satellite surveillance for intelligence and threat detection combines technologies **like high-resolution imagery, electromagnetic intelligence, and geospatial intelligence**.

These technologies enable **precise identification and tracking of military and civilian targets, interception of communications, and comprehensive strategic analysis**, through the interception of electromagnetic signals and data combination.

In the defence and security sector, satellite surveillance is now **integrated into command and intelligence centres**, enabling effective coordination of armed forces as battlefield surveillance and crisis monitoring.

Interoperability between allies, developing resilient constellations, security issues including secure transmissions, will define the future strategic challenges for space and military surveillance.

Key Technologies

Activable on a long-term basis

BLOCKCHAIN

Supply chain management, product and spare parts traceability

#1 Enhance the security, traceability and authenticity of information flows and transactions
#2 Reduce delays, fraud and errors

#1 Information security: confidentiality, integrity and transparency
#2 Ability to provide proof of authenticity throughout the life cycle of goods

Blockchain technology, a digital system for storing and transmitting information securely, functions as a decentralized and immutable ledger. The decentralised network of the blockchain enables each of its participants to check the validity of the information recorded at any time.

In the defence sector, it enhances **supply chain management by ensuring the authenticity and traceability of products and parts, optimizing logistics processes, and automating transactions, preventing misappropriation, theft, fraud, counterfeiting, unanticipated stock errors, or even loss of supplies**. Indeed, the army forces are quickly able to visualise the state of stocks, their location, their storage conditions, etc.

The main obstacle to a widespread adoption is linked to **scalability issues**. Another is the interoperability with all the other actors implicated in the defence sector, a challenge made all the greater by the lack of common governance standards.

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