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Additive manufacturing (AM), described as “key for the development of future military capabilities”, has created a range of new possibilities for both industrial and private actors. The manufacturing technique, colloquially known as 3D printing, produces objects layer by layer according to a digital 3D model. This report presents a unique overview of the sociotechnical environment of AM in the military technology sector, focusing on primary production and maintenance, repair and overhaul (MRO). It discusses the relevant actors, distinguishing between those within the conventional military domain and those outside of it, i.e. non-state actors self-manufacturing armaments. By showcasing real-life applications, the report offers insights into the factors influencing the industrial adoption and establishment of AM as a military capability.

Additive manufacturing is increasingly being used for the primary production of military platforms and systems, with notably higher readiness levels in the aerospace sector. Current applications across domains show that adoption is often hindered by high cost, certification challenges, such as long approval times, especially for load-bearing components, or resource-intensive design and development in general. Research into new materials and applications is ongoing but additional factors such as the need for extensive post-processing and partial reliance on destructive quality control measures further slow industrial adoption. In general, the military technology sector emphasises the importance of AM as a cutting-edge technology and a company capability but does not specify use cases and applications. Many applications are still awaiting trial to confirm their technical and economic viability. It therefore remains difficult to support the claim that AM is key for future military capability development.

Faster adoption can be seen in the realm of AM for MRO. Its importance lies in the ability to employ this technology for on-demand, in situ manufacturing of parts, thus allowing production and integration outside traditional maintenance hubs. Several armed forces are testing the extent to which AM can alleviate supply chain pressure and increase logistical operations’ responsiveness to unexpected demand, therefore more efficiently maintaining the military’s resilience and readiness. Given the challenges related to data security, interoperability, training and technical capabilities, more data is required to accurately scope and determine the military utility of AM in this area of operations. Efficiency also means understanding the relationship between AM and the “right to repair”. Based on the findings of this report, embracing AM as a military capability must involve repairability being built in by design, both technically and legally. This means that systems, platform designs and procurement contracts should, wherever possible, prioritise repairability by the armed forces themselves. This also presupposes that the armed forces have the capability and capacity to conduct repairs independently of the original equipment manufacturer (OEM).

This report describes, in several sections, how AM is used and deployed in the Ukrainian theatre. Both industrial actors and private citizens form nodes in a crowdsourced supply network that supplies the army. As such, it not only shows how lethal effects are achieved, with compared to industrial applications’ simpler 3D printing, but also exemplifies the professionalisation and adaptation of an ad hoc innovation that initially responded to a lack of materials and supply. Besides polymer-based products, replacement parts for conventional armaments have been printed with machines provided through international military assistance. While it is too early to assess the impact on Ukrainian

military logistics overall, this case study shows that additively manufactured components are now part of modern warfare, and can, if adequately integrated into weapon systems and their operation, deliver kinetic effects.

Lastly, this report provides an overview of the use of AM by non-state actors to manufacture increasingly powerful armaments. Although capability does not indicate intent, the development is concerning, especially regarding self-manufactured firearms. For some individuals and groups subscribing to a radical libertarian ideology, these weapons have become tools for acting upon their political beliefs, partially rooted in white supremacism. This development requires continuous observation. However, actors are diverse, and as the supply of 3D printed hardware to Ukraine and, for example, Myanmar demonstrates, technological advancements also enable formally non-aligned non-state actors to participate in warfare by providing military assistance alongside state-led supply chains. The full implications of these dynamics are yet to be understood.

Overall, AM will continue to be integrated in the military technology sector, though the lack of transparency hampers regulation efforts. Particular attention needs to be paid to export control considerations in the broader sociotechnical environment to ensure that actors are not using AM as a new tool to undermine current regulatory practices. Additionally, more data and evaluation are needed to gain insight into the utility of AM to scope the technology as a military capability, and to steer procurement policies and operational change in the appropriate direction.

Frankfurt, October 2025

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1. INTRODUCTION

In debates regarding the impact of emerging disruptive technologies on warfare and the military technology sector, additive manufacturing (AM) has emerged as one of the most tangible deployable technologies. Not only is it portrayed by the European Union “as a military capability enabler” (EDA, 2024) but has even been described as “key for the development of future military capabilities” (Clement, 2023). The technology enables an object to be directly manufactured by creating it layer by layer, following a 3D digital design, and has captivated engineers, hobbyists and security experts alike with its unique applications and as yet unclear potential – promising much but raising concerns for some. Indeed, visionaries believe AM has the revolutionary potential to unhinge whole societies, render conventional manufacturing obsolete and impact international security, such as through the possibility of printing weapons of mass destruction. While none of those “worst case scenarios” have materialised with the maturation and diffusion of AM, real-life examples in the military domain, such as the production of weaponry in Ukraine, demonstrate AM’s potential to have a deadly impact.[1]

The primary advantage of AM, colloquially known as 3D printing, is its ability to customise items or materials, and to use one machine to produce a variety of products with complex geometries. It differs from conventional modes of manufacturing that are often based on a subtractive process, shaping items by removing material, for instance through milling or cutting, rather than generating them by adding material. Use cases and applications are being studied across different industries. The goal of this research is to assess how integrating AM into manufacturing processes or even replacing traditional manufacturing with AM can harness new efficiencies. For this report, the relevant industries are aerospace and defence, as well as the hobbyist desktop printer sector. *In line with the general trend of increased military spending, the AM aerospace and defence sector has consistently grown, with an estimated market volume of €4.5 billion in 2024* (Reports and Data, 2024). This suggests that advancements in AM within the military technology sector carry significant economic weight. In comparison to other industries, military technology manufacturing faces unique challenges in adopting new production techniques due to the technically complex and security-sensitive nature of its products, rendering the integration of physical–digital systems into production lines especially complicated (Ullah et al., 2024).

Overall, a comprehensive overview explaining AM and its advancements within the military technology sector is lacking. This report addresses this information gap and, after briefly introducing the various technological processes, focuses, in subsequent sections, on the proliferation and use of AM for military purposes. *Understanding the complexity and diversity of AM provides a better sense of the limitations and expectations that characterise it.* The report details applications and use cases of actors both from within the military-industrial complex and outside it to broadly showcase technological developments and new capabilities that AM can bring to the armed forces and warfighting. This report aims to strengthen understanding of this new and exciting technology to inform adaptation, regulation and governance.

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1 Reports about the use of additive manufacturing in Ukraine strongly indicate that 3D-printed parts are being used to conduct operations and those parts play a substantial role to achieve a lethal effect

The report finds that many developments are still in the early stages of research or have not yet been implemented and expectations regarding AM's game-changing nature should therefore be approached cautiously. In the primary production of goods, the integration of new manufacturing processes, from prototyping to testing and adoption, is highly resource-intensive, and successful adoption relies on more than the technology itself. Depending on the military domain, different levels of progress can be observed. Overall though, military technology manufacturers are reluctant to share information about their production capabilities. While they do advertise AM as a crucial part of their portfolio, there is barely any public information about which parts of platforms are produced with AM, hinting at slow adoption for serialised products.

Contrary to the complex commercialisation of AM in the primary production of military technology, more advanced adoption is evident for military logistics, as industrial AM is already deployed in Ukraine for on-demand and local production of spare parts and other items. *"AM as a military capability" refers to precisely this capacity to respond on demand and in situ to material needs, ergo the ability to manufacture (replacement) parts independently of typical maintenance locations and schedules.* Mobile manufacturing solutions are being tested, and across different navies and even in space, AM is being trialled to achieve new efficiency for maintenance, repair and overhaul (MRO). More data and transparency by manufacturers and the armed forces are now needed to substantiate claims of increased efficiency and resilience. While AM is indeed rightfully characterised as an enabling technology, its categorisation as "key" for future military capability is often driven by expectations and hype without considering technical realities. Alongside technical limitations, such as minimal material diversity, low production efficiencies, and difficulties developing non-destructive quality control measures, companies, users, and authorities are confronted with a diverse array of contextual challenges, including intellectual property rights, regulations and standards, interoperability, and expertise, defining the scope of industrial adaptability. This shows that while AM can be used for diverse applications, the technology is embedded in a sociotechnical environment that must be developed at the same time to harness its actual technical benefits. *Despite these challenges, the development of AM as a military capability also ties into the broader debate about the armed forces' "right to repair".* Studies have already shown that AM has the potential to increase the responsiveness, resilience and readiness of the armed forces. Repairability by design and the capability to conduct the repairs are therefore crucial factors in reducing dependence on industrial suppliers and form the foundation for additive manufacturing as a military capability, as will be discussed later.

Actors outside the military-industrial complex have also shown a broad interest in additive manufacturing as a means to manufacture armaments. This group includes all actors producing or using 3D-printed armaments outside the established government-led supply chains, which means the state is not involved in the innovation, production or authorisation of the items. Hobbyists have gained unprecedented access to means of production through AM, which has given anyone with a relatively simple 3D printer the ability to print whatever they need, want or can imagine. And while far from all hobbyist users of AM are interested in manufacturing (parts of) armaments themselves, a small minority with the intent to do so now has the potential to participate in armed conflicts or access the means of warfare facilitated by the physical–digital character of AM (Cronin, 2020). In Ukraine, it is also apparent that 3D-printed parts are commonly used in drone warfare, for example for making improvised explosive devices, which are assembled by soldiers at the frontline by filling a 3D-printed shell with ammunition and attaching a detonator mechanism.

This report will first provide a technical introduction to AM (chapter 2), explaining the basic principles and main process categories of AM, and further contextualising the technology by discussing technical, practical, and other considerations affecting its use and broad industrial adoption. For those unfamiliar with AM, this section offers insight into its ecosystem, which is characterised by process diversity, complexity, and ingenuity, and is limited by many contextual factors, such as cyber vulnerability or quality control, which hinder wide and broad-scale industrial adoption.

Building on the general overview, the third chapter zooms in on the use of AM in the military-industrial complex. This chapter details how AM is (intended to be) used in the primary production of weapon systems and platforms and to what extent the technology is bringing and will bring advantages to military logistics operations, i.e MRO. An additional section is devoted to 3D-printed polymer items used in Ukraine.

The fourth chapter focuses on the use of AM by hobbyists and other actors outside the conventional innovation and supply chain in the military domain, i.e. the miliary-industrial complex. The chapter concentrates especially on the technology of 3D-printed firearms, the other types of self-manufactured items used in combat, and the nexus of AM with armed groups and right-wing terrorists.

Lastly, the report concludes by summarising the main findings. To substantiate, better understand and scope the effects of AM on military utility and readiness, more data needs to be made public, both by manufacturers and the armed forces. This section also points out the caveats in the AM–military technology nexus and emphasises the importance of regulatory approaches that consider the different factors shaping the sociotechnical environment of the actors analysed.

2. ADDITIVE MANUFACTURING – A POPULAR MANUFACTURING TECHNOLOGY

Since the invention of AM as a technology for building prototypes, a wide range of applications have been developed, rendering it a popular choice for novel design and manufacturing approaches. Hideo Kodama's system for solidifying photosensitive resin using UV light, published in 1981, is often regarded as the first AM process. Since then, many others have emerged (see Figure 1), frequently upholding the original concept of instant production.

On the one hand, the simplicity of certain processes, such as material extrusion, provides hobbyists with an accessible option for producing parts. On the other hand, a range of complex processes has emerged that are employed for industrial applications. These include products using powder bed fusion (e.g. the German EOS M300 metal printers), which are less readily adopted than plug-and-play solutions for home users, such as desktop 3D printers (e.g. Czech Prusa MK4S). This has resulted in AM acquiring different reference names, such as on-demand manufacturing, instant prototyping, and, most notably, 3D printing. One of its unique features is the ability to create complex structures as a single piece, whereas conventional manufacturing processes often require a complicated assembly of several components. The option to print items at home allowed individuals to prototype and manufacture objects, enabling entirely new forms of co-creation and user innovation (Rayna et al., 2015). Through this "democratisation" of the means of production, AM now enables greater independence from global supply chains. While hobbyist developments are not always easy to translate into or intended for industrial applications, they form the backbone of the "maker movement". This community comprises people with diverse interests and backgrounds creating and inventing objects independent of commercial organisations, often forming "maker spaces", in which resources are shared to develop open-source innovations efficiently (Beltagui et al., 2021). This dynamic, which often uses simpler AM processes without competing with industrial production, is a defining characteristic of the social value of AM.

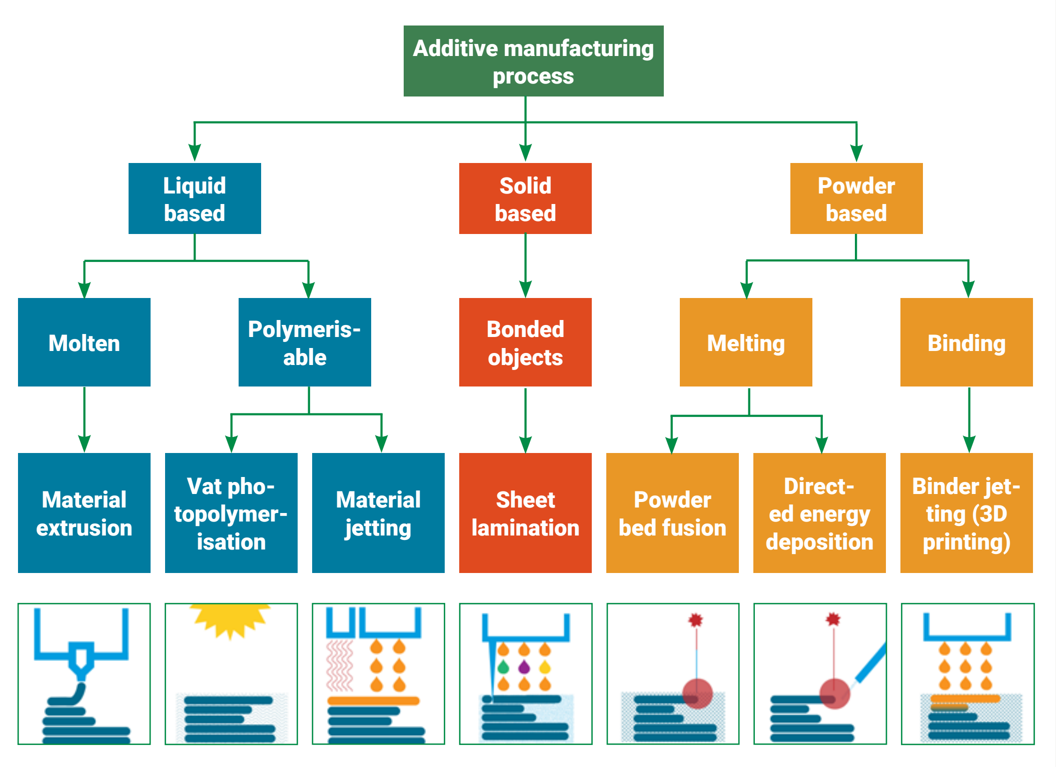

Figure 1: AM process categories according to international norm DIN EN ISO/ASTM 52900

2.1 FROM DESIGN TO A FINISHED PRODUCT: THREE PROCESS STAGES

A description of the process categories can be found in Table 1 which introduces the basic principle behind the creation of layers in each process. The categorisation follows international norm DIN EN ISO/ASTM 52900, which defines the general principles, fundamentals and vocabulary. As such it does not cover every print procedure that has developed using the same mechanisms for layer creation.

Process category	Underlying principle	Creation of layers	Characteristics
Material extrusion/ fused deposition modelling	Material is molten and solidifies when cooling down	Deposition of molten material through a heated nozzle, which solidifies and bonds to the previous layer upon cooling	Quick production of functional parts from diverse materials, often thermoplastic polymers, albeit often with poorer mechanical properties
Vat photopolymerisation	Solidification of liquid light-sensitive polymers by curing with light using vat photopolymerisation (VAT)	A platform travels vertically while the curable resin is kept in a vat and applied to the previous layer after curing	Highly accurate and customisable, often used in industries requiring such characteristics (e.g. healthcare)
Material jetting	Solidification of material with light or heat	Deposition of material droplets from a printer jet, which are then cured with UV light, hence the name "material jetting" (MJ)	High-resolution, multi-material solutions with a variety of surfaces and colours, but resulting parts are less durable and unsuitable for structural use
Sheet lamination	Bonding of solid state layers of material with either adhesives, heat or pressure (laminated object AM), or ultrasound (ultrasonic AM)	Stacking and bonding of thin material sheets. The material is fed from a spool that provides new feedstock after the required material is cut from the sheet and bound	Depending on the principle used, weak mechanical properties, but allows for integration of sensors between layers
Powder bed fusion	Melting or sintering powder particles together, which then solidify when cooling down	A layer of powder is deposited on the build platform and then selectively melted or sintered with a laser or electron beam depending on the design. The platform then moves vertically according to layer thickness and a new powder layer is applied	Creation of complex geometries and structures with good mechanical properties and no need for support structures. A wide range of materials can be processed but production often requires a controlled atmosphere and extensive post-processing
Directed energy deposition	Melting of metallic feedstock onto a surface that solidifies when cooling down	Continuous deposition of material through a nozzle as powder or wire, using heat from a laser, electron beam, or plasma arc	Fast build speeds and creation of bigger components, including diverse metal alloys, but challenging due to extensive post-processing as well as complexity of process parameters such as bead formation, deposition rate and temperature, which can lead to issues such as cracks and pores
Binder jetting	Heatless solidification of material through deposition of binder	Binder droplets are deposited on a powder bed then build platform is lowered according to layer thickness. This is followed by reapplication of a new powder layer after each deposition	Low residual stress in parts compared to other powder-based processes. Can be built without support structure, but parts are often porous requiring post-processing

Table 1: Descriptions of AM process categories

Across the different process categories, three process steps characterise AM manufacturing: design, processing and post-processing. The degree of complexity of each step depends on the use case or application.

2.1.1 FIRST STEP: DESIGN PROCESS

The design phase involves creating a digital model of an object, typically with computer-aided design (CAD) software. This model is a three-dimensional virtual representation of the geometries and details of the final part. Thanks to fewer manufacturing constraints in the second phase of AM, intricate features, such as lattice structures, internal channels, etc., can be imagined digitally. This brings its own challenges, however, because new designs also need to maintain their functionality and uphold the structure, which is especially relevant for lightweight constructions and designs (Gibson et al., 2015). After the initial design, the model is converted into a machine-readable format such as standard tessellation language (STL). This step links the design with the production stage, as the software converts the 3D model into a representation comprising many triangles and prepares for slicing. Slicing means transforming the model into a "G-code", consisting of thin 2D layers that guide the printing process with details such as temperature and layer thickness.

2.1.2 SECOND STAGE: MODEL PRODUCTION

The second step involves the layer-by-layer production of an object following the information ascribed into the G-code. Different chemical or physical principles are used to create the layers and ensure cohesion (see middle row of Figure 1). In some processes, molten material from the feedstock is deposited on the building platform and cured – hardened – as it cools down. Some processes use liquid photopolymer, a substance that reacts to UV light and solidifies upon exposure in a process known as photopolymerisation. Layers can also be created by bonding objects, i.e. binding sheets of metallic materials together through ultrasound welding or laminating. And still other processes involve melting or sintering material layers directly to each other. These use lasers to melt/sinter the feedstock and surface layers of the previously deposited material, thereby fusing them together. Lastly, there is binding – a heatless process in which a glue or other chemical binder is deposited on powder, leading to the material sticking to itself. In this second stage of production, depending on the final item required, the engineer has to choose a combination of four parameters that determine the characteristics (physical, mechanical and visual properties) of the final object:

- Type of material (polymer, metal, ceramic or composite material)
- Material form/state (powder, filament, liquid, etc.)
- Principle used to fuse or connect materials (melting, photopolymerisation, etc.)
- Machine architecture

These four parameters demonstrate the importance of materials science in AM, embodying the physical aspect of AM's physical–digital nature. This list of parameters represents the most condensed version of what must be considered. Numerous process parameters, such as deposition speed, temperature, viscosity, etc., are influenced by these four fundamental parameters and their interactions.

2.1.3 FINISHING PRODUCTION: POST-PROCESSING

Lastly, when the final object is extracted from the printer, it typically requires some post-processing to meet the desired mechanical and visual requirements. Post-processing ranges from relatively simple cleaning of unbound powder or removal of support structures to more complex processes. Support structures are the constructions or additional material needed to support overhanging features or those requiring support during printing. Post-processing is especially complex for metal parts, as these often require a smooth surface, which is challenging to achieve during the printing process. These parts may therefore need to be milled and polished. Such treatments fulfil more than just an aesthetic function, as surface roughness influences the performance of the parts, such as their fatigue behaviour or dimensional accuracy (Maleki et al., 2021). To further prevent other defects in metal parts, such as cracks, delamination, distortion or failure due to residual stress, parts are heat treated, e.g. using annealing or sintering. For parts made from polymers, for example, sanding is often required to smooth the surfaces.

2.2 PRACTICAL CONSTRAINTS OF AM

Although AM is already widely diffused among hobbyists, certain practical constraints limit its broader use in industrial manufacturing. *These limitations, while also affecting hobbyists, are more pressing in an industrial context as they must always be considered when assessing economic viability and efficiency.* The most urgent issues posing economic challenges are the limited availability of materials and quality control considerations.

2.2.1 A NOVEL TECHNOLOGY AND LIMITED AVAILABILITY OF MATERIALS

Each material and AM process presents unique challenges and limitations. Generally, these concerns involve object size, printing speeds, material diversity and functionality, surface quality, and costs (Zhou et al., 2024). First, *printer size determines the size of the printed object and, consequently, the ability to take advantage of design flexibility in terms of dimensions*. While some niche applications can print fairly large items, such as 3D-printed concrete houses, or tiny items such as sensors of sizes in the realm of nanometres and microns (Huang et al., 2023), most machines cannot accommodate such a wide scale and are restricted to the size of the building platform and possible resolution (degree of detail or “fineness” that a printer can produce). Besides size, *printing speed currently prevents a universal adaptation of AM*. This is a process parameter that determines the quantity of items produced within a given time frame, thereby significantly influencing process efficiency. The printing speed [mm/s] depends on the volumetric flow, ergo the volume a printer can create per second [mm^3/s], the layer height [mm] and line width [mm]. Depending on the material, deposition rates must be tailored to the specific material being processed to ensure the desired final characteristics.

Owing to the technology’s relative novelty, the behaviour of materials processed with AM is comparatively less well understood. Metal casting, for instance, has been used for several thousand years, leading to a solid understanding of its material properties. The lack of tacit knowledge and experience limits material diversity, performance and therefore the widespread adoption of AM. The layering of materials renders it difficult to mitigate residual stress and attain specific mechanical characteristics and properties. The material properties within and between layers can differ, affecting and introducing direction dependent mechanical properties, which in turn impacts factors such as the tensile strength of metallic or multi-material objects, for instance (Hasanov et al., 2021). Depending on the use case, thermal, electrical or magnetic properties, etc. can also play a role in the production of items.

In addition to ensuring the functional mechanical properties of 3D-printed parts, *surface quality is another factor that challenges the broad adaptability of AM*. Irregularities due to the layered structure are common when new material solidifies on top of the previous layer. These can be introduced by thermal gradients leading to uneven solidification, by irregularities in the surface influencing the next layer, by raw material faults, or even by temperature and humidity in the printing chamber. In post-processing, surface treatments are often necessary to achieve the desired aesthetic outcomes, smoothing out the surface, prolonging the overall manufacturing process and increasing the amount of manual labour. These treatments should, however, be seen as more than just an aesthetic choice, as they can be crucial for a component's function, especially in applications – such as in medical devices or gears – characterised by small tolerances. One way of limiting post-processing can be to print in lower resolution, though finer resolution increases print times because of the reduced volumetric flow.

Lastly, *high costs hinder companies' adoption of AM*, as printers, supporting software, training and expertise are a considerable investment. The hardware itself ranges from €200 for and entry-level printer to over €100,000 for an industrial 3D printer, though most professional machines range between €20,000 and €100,000. While machinery can amortise over time, other costs associated with the production process, particularly human labour, are integral to financial efficiency calculations. As mentioned above, the scope of manual labour differs by use case, and influences the decision on whether AM is the more efficient production choice. Furthermore, costs linked to process failures in the large-scale or mass production of complex AM-manufactured items hinder its widespread adoption (Ding et al., 2021).

2.2.2 BALANCING EFFICIENCY AND QUALITY CONTROL

The focus thus far has been on efficiency, i.e. ensuring a specific output in relation to financial costs. Quality assurance is at the core of this balance, whether for a single product, a process or an entire production line. While it is often claimed that universal standards facilitating a reliable quality control regime are yet to be developed, the reality is more nuanced, with quality control protocols in place despite a number of caveats. Parallels with conventional manufacturing exist, particularly in metal AM, and established quality control methods, e.g. experimental quality monitoring methods such as the analysis of acoustic signals, can be applied to AM manufacturing processes (Lee et al., 2021). In terms of practicalities, *the main quality control challenge is that thorough testing of the mechanical properties of a component often requires the destruction of that component, rendering it unusable*. Destructive testing is necessary to examine the material properties, which are already understood for other manufacturing processes, making the production of serialised goods quite costly and time consuming. Nevertheless, findings from destructive testing can be leveraged to enhance the production process and monitor parameters non-intrusively, ensuring process reliability and minimising the need for future destructive testing. At present, many non-intrusive methods necessitate highly specialised machines and materials. However, recent advancements in machine learning (ML), along with various sensors, are being investigated to enable in situ monitoring of the manufacturing process, simplify the complexity of ex situ quality control, and could potentially be integrated into the machines themselves (Charalampous et al., 2020).

2.2.3 LOOKING FORWARD: TECHNOLOGICAL ADAPTABILITY FOR MASS PRODUCTION

Overall, AM will be increasingly integrated into industrial production processes as more materials become available for printing, i.e. more materials which can efficiently produce reliable and replicable items with AM. For low-volume mass production of certain complex parts, AM is already a viable alternative to traditional manufacturing (Achillas et al., 2017). Examples are John Deere's tractor thermal diverter valves, whose production with AM is half the price and due to complex internal features, impossible to make with conventional types of manufacturing (Schwaar, 2022); or medical implants, such as hip replacement implants or hearing aids, for which AM offers a more affordable solution, as the complex geometries are more expensive, time consuming or even impossible to produce otherwise. This shows that *AM will become an additional option for highly specialised manufacturing in distinct settings*, but not substitute huge parts of mass production manufacturing. For some items, there will continue to be more cost and efficiency constraints than in mass production , even though AM is evolving (Dias et al., 2022). Considering the challenges of high-energy consumption, laborious post-processing and, for some applications, extended lead times, financial considerations alone do not determine the further adoption of AM; progress in materials science and engineering are crucial to improve and expand the material options available for AM as well.

2.3 CYBER VULNERABILITY AND ENVIRONMENTAL SUSTAINABILITY

Lastly, it is essential to consider both the security of the digital and physical technologies involved and environmental sustainability when applying and integrating AM. In terms of cyber vulnerabilities, possible new threats include disruptions to the production process through manipulation, such as causing defects by altering the tempering process parameters or changing the CAD file containing the digital 3D design, as well as theft of files, which ultimately compromises the systems' operational integrity (Mahmood et al., 2024; Prinsloo et al., 2019). Other disruptions could occur along a machine's supply chain, such as the introduction of counterfeit components or "backdoors" embedded in the machines themselves, which facilitate unauthorised communication with the device by external actors (Hammi et al., 2023: 6). *The extensive "attack surface" of physical–digital systems permits both external and internal actors to pose a risk and vulnerability*, further igniting concerns about industrial espionage (Hammi et al., 2023). Mitigation measures and approaches for secure data exchange exist, such as the Trusted Information and Security Assessment Exchange (TISAX), and are already in use. However, it remains to be seen to what extent these frameworks are achievable for small and medium-sized enterprises (Mahmood et al., 2024; VDA, 2025). Additional concerns related to *AM and* *digital supply chains in general are new vulnerabilities regarding copyrights and intellectual property* (IP). These vulnerabilities are twofold: first, there is misappropriation, theft and similar actions, while the second vulnerability concerns the infringement of others' IP, impacting both the security and integrity of design data (Adu-Amankwa & Daly, 2023).

While new technical possibilities are a vital feature, the ability to establish more sustainable production lines and operations has significantly influenced public perceptions and the "revolutionary" nature of AM. The latter is based on the idea that AM allows for more material-efficient processes requiring only the raw material needed for the final volume, unlike conventional manufacturing, in which items are often shaped by removing material and, therefore, creating scraps. Furthermore, AM applications could be designed to recycle and produce recyclable components, fostering independence from supply chains due to their flexibility to manufacture various products on-site, thereby also reducing emissions from transportation (Javaid et al., 2021). While these claims may hold some truth, *it is not yet possible to characterise AM as a sustainable technology*. To render it more sustainable, further research is required to reduce energy consumption, enhance part durability and mechanical properties, improve recyclability and the use of renewable raw materials, and increase efficiency across all three processing stages, while adopting AM in a way that promotes overall environmentally sustainable operation (Acierno & Patti, 2023; De Sousa Alves et al., 2024; Mani et al., 2014).

3. ADDITIVE MANUFACTURING IN THE MILITARY TECHNOLOGY SECTOR

While AM is being researched across industries, this report focuses on the military technology sector because the (possibility of) armament production is quite different from the manufacturing of civilian goods: not necessarily technically, but politically, legally and ethically. Additive manufacturing can be used for both military and civilian purposes making it a dual-use technology. Therefore, an understanding of the technical and military realities in the industry, on the ground and across different types of actors is essential for its control and governance. In the military technology sector, AM is explored as a way of reducing production costs by partially substituting expensive conventional production lines and alleviating pressure on supply chains. One way of doing this is to examine existing military platforms and systems to determine how they could be produced or optimised with AM, or to design entirely new parts that were previously impossible.

The following sections provide an overview of how AM is used by conventional actors in the military domain, i.e. the military-industrial complex. This includes all actors producing military technology to be used in the state military or other sectors with similar material demands, both companies and the armed forces themselves. This chapter will focus on using AM to enhance the efficiency of primary military technology production, as well as generating new efficiencies in MRO, and logistics more broadly. Many AM applications in primary production have not yet been serialised or are still in the early stages of research. Adoption varies widely across domains and use cases, with the aerospace sector currently having the most applications with higher technical readiness levels. It is clear that high costs, security considerations – for the users, data and broader public – as well as quality control and strict certification standards hinder manufacturers from efficiently using AM for the serialised production of platforms and weapon systems.

Several national armed forces recognise a clear advantage in training their soldiers to adapt to AM, and the European Defence Agency (EDA, 2023) also focuses on the "capability development" of AM. Continuous research is underway and several AM applications are being tested. Mobile solutions for use within the armed forces to alleviate pressure from logistics operations are one of the main developments helping AM become a military capability. Reports document the use of shipping container-sized mobile factories in which spare parts for weapon systems are printed in Ukraine, and different companies have participated in NATO exercises testing their mobile factories.

3.1 PRIMARY PRODUCTION AND DESIGN OF MILITARY TECHNOLOGY

Primary production involves designing and manufacturing new items that are delivered to the end user for their initial use. As armies receive and consume an immense volume of items across many product groups, it is difficult to estimate the extent to which AM has already been integrated into the primary production of military technology in general. Some sectors, specifically aerospace, however, have shown significant interest in AM and this is expanding to others, too, such as those building land platforms.

3.1.1 AERONAUTICS INDUSTRY – COMPLEX AND LIGHT

In the aeronautics industry, AM is generally used for producing components, prototypes and tools, as well as for repairs, primarily processing polymer or metallic materials (Alami et al., 2023). *The known use cases listed below highlight important applications, such as building complex components for different assemblies in aerial vehicles and missiles, as well as lightweight designs. However, the lack of documented serialisation of AM-manufactured parts emphasises the challenges associated with adopting a new manufacturing process.*

The most prominent process categories in this industry are directed energy deposition and powder bed fusion used to process metals, since they allow for the creation of dense parts with complex geometries, either bigger in size or more intricate, respectively (Blakey-Milner et al., 2021). As in other industries, the primary motivation is to save both time and money and AM enables scalable production on demand, shortens lead times through quicker prototyping, and facilitates the creation of lightweight geometries and designs with intricate internal features that enhance and optimise thermal management (Alifui-Segbaya et al., 2023).

Concrete examples are listed below, documenting use cases of AM-made items in airplane models that are primarily used in civilian but also in military applications, with advances in one domain informing progress in the other and vice versa. It is, however, not possible to verify for each case whether the 3D-printed parts are definitively incorporated into the series version for military use. First, there are additive-manufactured fuel nozzle tips for LEAP engines, part of the injector mechanism for fuel into an engine's combustion chamber: AM enabled the construction of the nozzle as a single part, previously made of 18 cast components (GE Aerospace, 2018). Another example is the titanium flexshaft for the Airbus A350's high-lift system now produced with AM and previously comprising seven components (Liebherr, 2024). Even cabin components, such as overhead storage parts, are being additively manufactured to make them lighter. Other documented applications in aviation include wingtip fences for the A320ceo, a titanium part for the engine's ice protection system – the first aviation-certified load-bearing metal component – and U.S. Air Force engine parts (Ebner, 2025; Rangell, 2020). Owing to their relatively straightforward design, larger plane components, such as the fuselage or empennage, are unlikely to ever be made with AM.

Details about AM components in explicitly military aviation are limited, with public information mainly referring to AM as a company's capability and unspecified integration into production chains. Boeing is reportedly testing 3D-printed main rotor linkages for their Apache helicopters, using large format metal printers (Judson, 2023). Other notable examples of explicit military use cases include uncrewed aerial vehicles (UAV) and missile propulsion systems. Smaller fixed-wing drones, such as those by Donaustahl GmbH, are "3D-printable" and three UAVs were supplied to the Ukrainian Armed Forces (UAF) for testing (Nikolov, 2023). Further, US company Firestorm Lab received $100 million in early 2025 to develop 3D-printed drones for the U.S. Air Force (Listek, 2025). There are no publicly accessible progress reports on advancing 3D-printed fixed-wing UAVs beyond testing and experimentation. However, rising investments from US public authorities and venture capitalists signify a strong belief in their utility.

As to missiles, known examples include 3D-printed fins and guidance systems, such as in Lockheed Martin's Mako hypersonic missiles and their engines (Tyrer-Jones, 2024b). Solid rocket motors (SRM) and components for missiles, in particular, have been tested in light of a surge in US demand for missiles driven by state military aid for Ukraine and Israel (Everstine, 2024). Given the complexity of propulsion systems, manufacturers hope to streamline production using the benefits of AM printing (Brockmann, 2021). The 3D-printed items are envisaged for the U.S. Navy's standard missile program, long-range SRMs for RTX missiles developed and tested by Ursa Major, and for propulsion systems built by Avio, which produces, among other things, surface-to-air missiles for European armed forces, air defence missiles and other tactical military missiles (Mishra, 2024; Tyrer-Jones, 2024a). The outcome of these tests is yet to be communicated, and it is unclear to what extent 3D-printed SRMs are serialised.

3.1.2 SPACEFARING – A NEW INDUSTRY

Additive manufacturing in spacefaring involves constructing items for space flights or transport, and producing items within space's microgravity. Despite differences in ballistic missiles and space launch systems, aviation and space technologies overlap, especially when it comes to propulsion systems and lightweight, temperature-resistant materials.

The innovation introduced by AM is particularly intriguing for what is known as the "NewSpace" industry, which has developed in recent years to capitalise on access to space and spawned a variety of new actors and start-ups. The extent of military contracts is hard to estimate due to the dual-use nature of satellite and launch capabilities. Space has become an essential domain for the military and another arena of geopolitical competition in recent decades. This is mainly due to its strategic importance as another domain in which to project power and defend assets, as well as the increased dependence of military operations on space-based systems for communication, reconnaissance and navigation. *Some of the emerging small and micro-launch systems developed by NewSpace actors resemble missile launch systems, making progress in this sector relevant for the military domain as well* (Brockmann & Schiller, 2023).

Examples of AM in spacefaring include British Airborne Engineering testing nozzles with cooling gaps to extend rocket engine life and reusability (E. Moore, 2024) and NASA successfully testing a lighter 3D-printed rotating detonation rocket engine, which could potentially increase payload capacity by replacing heavier engines (Ridgeway, 2023). Rocket Lab USA's Neutron rocket, due to be launched in 2025, features nine 3D-printed engines, as well as various other 3D-printed components like the main chamber and turbopump housing (P., 2025b). Another example is Relativity Space's Terran R, which is a fully 3D-printed reusable rocket using proprietary AM processes and materials planned to be commercially launched in 2026 (Relativity, 2023; 2025). Other items researched in the aerospace sector include the printing of propellants, structural components, thermal management systems, and various electronic parts and instruments for use in space (Ghidini et al., 2023). Based on these developments, NewSpace actors appear to have reached quite high levels of technical readiness, also successfully using AM for bigger components. Commercial launches will be needed to show the extent to which AM is a viable option for manufacturing rockets.

3.1.3 AM FOR VEHICLES IN THE LAND AND MARITIME DOMAIN

Requirements for land and maritime vehicles are quite different to those in the air. Not only does the use context differ, but so too do the environmental factors impacting the platforms in the land and maritime domains. These vehicles are further designed to withstand kinetic impacts in combat and physically protect the crew inside. *Additive manufacturing in these domains has largely been reported as a capability for repairing or maintaining platforms rather than for primary production, though some examples of the latter do exist.*

Unlike the aerospace industry, which benefits from broad civilian and military overlap, there is less intersection between civilian cars and armoured vehicles or tanks, and fewer published research or articles. One article describes how parts of the British Challenger 3 tank and Boxer vehicles produced by Rheinmetall BAE Systems Land are manufactured with AM, along with spare parts for both systems (Tyrer-Jones, 2025b). No further details have been made public regarding the specific parts manufactured using AM and the process used. Another project seeks to create monolithic underbody hulls for military vehicles, using a machine specifically designed to manufacture large metal components for the U.S. Army Rock Island Arsenal (Jones, 2023). The project began with the initial proof of concept for a large-area AM system to print components for legacy military vehicles, such as tooling, moulds, and steel and aluminium parts, demonstrating that certain aspects of vehicle production with AM are feasible (Love et al., 2016).

Maritime vehicles also use parts made with AM. That said, although some instances of AM application in military shipbuilding exist, the naval industry, known for its reliance on traditional manufacturing for ship longevity, may be more cautious about adopting the technology than other sectors. Most notable have been the ship propellers, manufactured with wire arc AM (WAAM) by Naval Group and in another project by Damen Shipyards (Essop, 2019; Haria, 2017). These 300–400 kg propellers are made using a robotic arm that welds layers, enabling the production of large metallic shapes. While prototypes and demonstrators were successfully printed at the end of the 2010s, Damen reported having never serialised its "WAAMpeller" due to high production costs and complex regulatory burdens. A more recent project announced its plans to meet the challenges of AM in shipbuilding: a consortium including EOS, Saab and AMEXCI intends to develop 3D-printed parts for new corvettes for the Finnish Navy, though no details on exactly which parts have been made public at this point (AMEXCI, 2025). For submarines, a metal impeller as part of a bigger component produced by Curtiss-Wright Corporation was supplied to the U.S. Navy in late 2024 to be integrated into its fleet but no further information about the status of the project is available (P., 2024b). Another example is AML3D's copper-nickel tail section – produced in under five weeks, compared to the usual 17 months – which awaits testing before further trials on board, demonstrating that research into AM for the production of submarines is underway, though it is too early to confirm the product's viability (Tyrer-Jones, 2025a). Lastly, in 2017, Oak Ridge National Laboratory and the U.S. Navy famously revealed a carbon fibre composite submarine hull made on a large-area AM-fused material deposition machine. This SEAL Delivery Vehicle, designed to transport staff and materials, was supposed to be tested under real-life conditions in 2019 (Jackson, 2017). Though often cited as a proof of concept for AM's capability to produce submarine hulls, there is no information available on further prototyping or testing after 2017. This implies that the technology fell short of expectations in practice, underscoring the technological complexities and potential limitations of integrating AM into the primary production of larger components in the maritime sector.

3.1.4 ARMOUR AND OTHER APPLICATIONS

Besides platforms across various domains, smaller components and subsystems are also being researched to determine the potential for increased efficiency using AM. Regardless of the domain, armour is a crucial military component, and AM holds the promise of lighter, more complex, multifunctional or dynamic armour designs due to its ability to create new geometries and efficient processes. Of particular importance is an understanding of which raw materials, when combined with specific processes, exhibit good blast resilience capabilities, such as energy absorption and hardness. *Various materials, including metallic alloys and polymers, as well as different structural types, are being researched to develop cost-effective and lighter armour* (Colorado et al., 2023). While armour made from polymers generally seems less protective, researchers are experimenting with 3D-printed structures at the nano level. For instance, lightweight "nano-architected" materials made from photosensitive polymers use lithography AM and demonstrate better energy absorption than steel or Kevlar (Bisić & Pandžić, 2024; Portela et al., 2021). Another potential approach is to use AM for processing expensive titanium – a material with advantageous characteristics for ballistic protection – to develop new lightweight ballistic protection applications (Lui et al., 2022; Straßburger et al., 2023). Due to the creation of scraps when using subtractive manufacturing, titanium items are currently very pricey but could become more affordable with AM as less scrap material would be produced. Some

3D-printed ballistic protection parts have already reached high levels of technical readiness, such as products by Mehler Protection, specifically the PROTEC3D product line of selective laser melting-produced steel armour plating, which, according to the manufacturer, is already built into civil protection vehicles, fulfilling NATO and other ballistic protection standards (Mehler Protection, 2025). These examples demonstrate that it is technically possible to manufacture armour with AM, though the extent to which these solutions will be adopted remains to be seen.

More prototypes and diverse research on the use of AM in the military technology sector exist, though primary production with AM is often still in the early stages of development, and research has only just begun. Some examples are:

- Functionalisation of carbon fibre-reinforced plastics with radar-absorbing structures (Bundesministerium der Verteidigung, 2024)
- Production of radio frequency devices, such as antennas (Helena et al., 2020)
- AM of energetic materials, i.e. explosives, pyrotechnics, propellants and warheads, for customisation and to increase the efficiency of the energy being released (Chen et al., 2022; Kumar et al., 2022)
- 3D printing of functionalised biomedical sensors and applications to monitor combatants' health (Bird & Ravindra, 2021)

Based on the above examples, it is premature to predict the future adoption of AM for serialised primary production of military technology. While manufacturers often do not detail the problems they encounter in their manufacturing process, the difficulties mentioned in the previous chapter also apply to the military technology sectors. Limited availability of materials, extensive post-processing, challenges concerning technical capability and scalability of applications, as well as financial considerations will continue to inhibit companies from increasing their reliance on AM. Cyber vulnerabilities and sustainability also influence the decision to adopt AM. It is clear, though, that AM can fulfil essential functions within manufacturing, offering considerable potential for quick prototyping and specific applications, most likely for non-load-bearing parts. Alongside these advantages, AM has also enhanced companies' public image, as many military technology producers emphasise their AM capabilities without detailing the technology and use within their manufacturing process.

3.2 ZOOMING IN ON UKRAINE: POLYMER-BASED 3D PRINTING IN WARFARE

Technology has been a crucial part of the war in Ukraine. Alongside conventional armaments from Ukraine and other countries' military aid, a wide range of simpler 3D-printed items have been documented on the battlefield. Although the industry is the main producer of military hardware used at the frontline (artillery, armoured vehicles, etc.), civilians are developing and supplying 3D-printed items and other material to the UAF, an effort shaped by its collaborative character. The volunteer-run Druk Army, for example, reportedly delivered 11 million 3D-printed units (around 277 tons of material) to the frontlines in 2024 (Counteroffensive Pro, 2025). There is limited information about the logistical supply chains, but it is known that Ukrainian companies are now also supplying the Ukrainian army with 3D-printed items. *Hence, both industrial and hobbyist actors are now supplying the UAF, forming nodes* *in a crowdsourced supply network*. Drones have become ubiquitous in warfare. These are partially constructed from 3D-printed parts, such as structural components for rotary-wing drones, which drop 3D-printed modified grenades. Designs and use cases have evolved since the introduction of 3D-printed additions (e.g. stabilising fins to attach to grenades) and now consist of complete items, such as larger improvised ammunition for the "Baba Yaga" drone (see Figure 2).

Figure 2: Non-standardised improvised ammunition for Ukrainian "Baba Yaga" drone. Photo courtesy of Jordan Linn. Source: https://www.linkedin.com/posts/jordanrlinn_payloads-on-ukraines-baba-yaga-vampire-activity-7286778507991408640-A3zH?utm_source=share&utm_medium=member_desktop&lipi=

This ammunition uses explosives presumably sourced from conventional armaments and a shell filled with shrapnel; the grenade is then detonated using a modified fuse. In this example, the entire outer layer is 3D-printed, making the grenade lighter than conventional metal ones thus increasing drone range while reducing the amount of explosives needed to destroy the shell. Other examples of improvised explosives built with a 3D casing are anti-personnel (AP) mines, which use a simple design and packing technique to enable quick assembly and arming near the frontlines (The Armourer's Bench, 2024). Social media reports have even described a 3D-printed holder for the smaller PFM-1 AP mines ("butterfly mines") that can be attached to a drone and programmed to drop up to 20 mines during flight, effectively turning drones into minelaying systems (Linn, 2025). It can be assumed that more items and use cases are being used on the frontline in Ukraine. However, it is currently impossible to estimate how far specific designs have spread homogenously and to what extent these products are standardised or only prototypes. While the polymer grenade casings made on a desktop printer are quick, simple and cheap to manufacture, there is no publicly available information on conventional arms manufacturers using this approach, which is most likely due to security concerns when transporting and handling the devices. Although a brittle shell is useful for achieving greater effect with less explosive, it can be dangerous to handle these devices during manufacturing, transport, arming and placement, as the shell could break or the explosive and fuse malfunction. *Overall, 3D printing of polymer parts has become a characteristic feature of the material supplied for armaments in Ukraine. It is an example of the professionalisation and adaptation of an ad hoc innovation that initially responded to a lack of material and supplies.* To accurately assess the military effectiveness of these printed items requires a systematic analysis of data. *What is already clear however is that once they are properly integrated into a weapon system and its operation, AM-produced parts are used by both Ukrainian and Russian soldiers to deliver kinetic and/or lethal effects.*

3.3 AM IN SITU: PRODUCTION OF PARTS BEYOND MAINTENANCE HUBS

Additive manufacturing has become a sought-after capability for in situ printing and supporting MRO. In situ here means activities occur at the actual location of operation, such as on a military base, a naval vessel or near the frontlines. The term MRO describes all processes and activities that ensure the operationality of equipment, which either take place in situ or in maintenance hubs. In various domains, mobile AM solutions have been tested and deployed to increase armed forces' creativity, experience and expertise regarding in situ production, thereby reducing dependence on logistical supply chains for certain components in both peacetime and conflict situations.

Meeting the material needs of armed forces is a significant and somewhat complex endeavour due to the variety of items required for daily operations, their intricacy or age. Some military systems have been in use for several decades, thus forcing the OEMs and the armed forces to produce and store spare parts for systems that may no longer be manufactured. This necessitates storage space and/or the maintenance and upkeep of production lines, as well as expertise to produce legacy system components. Additionally, maintenance schedules can be difficult to keep, particularly when combined with supply chain issues and a downturn in certain industrial sectors, such as shipbuilding, that are responsible for manufacturing specific components.

While maintenance in peacetime is already challenging but still plannable, a crisis or combat situation presents logistics with considerably different material needs, particularly for mechanised troops, as demand for spare parts is difficult to predict. Additive manufacturing has the potential to enhance a troop's performance, as it reduces dependence on warehouse stock or dysfunctional systems, allowing stakeholders to react to unpredictable demand (Rautio & Valtonen, 2022). *The concept and significance of "AM as a military capability" therefore often refers to on-demand in situ printing, enabling the production and integration of parts beyond the typical maintenance hubs*, such as at a military camp, near the frontline, at sea or in the field during exercises. Locations like these pose particular challenges for military logistics given the extended lead times to meet a sudden increase in the demand for replacement parts necessary to maintain combat capability. During the US invasion of Iraq, for example, it took an average of 40 days for replacement parts to arrive (T. A. Moore et al., 2018). This delay can be even greater in the case of nationally mixed units with different material or even the use of captured weapon systems, where a direct delivery of spare parts is, in many cases, impossible.

Overall, the desired effect of AM for MRO, as indicated by and simulated in studies, is to enhance armed forces' responsiveness, resilience and readiness (Boer et al., 2020; T. A. Moore et al., 2018; Santos González & González Álvarez, 2018; Valtonen et al., 2022, 2023). The extent to which these effects are achieved and translated into a tactical advantage, i.e. the extent to which the capability enhances military readiness, remains uncertain, as there is currently no public information regarding the systematic integration of AM into the military, apart from its use in the Royal Netherlands Navy (see below) and for testing purposes.

3.3.1 "PARTS OF CONSEQUENCE" AND REPAIR IN UKRAINE

Systems for MRO provided through military assistance have been fielded by the Ukrainian Armed Forces: the United States provided "industrial-size 3D printers"[2] for the production of repair parts in late summer 2023 (unspecified machine types) and Australia provided SPEE3D's Cold Spray AM machines (SPEE3D, 2023). The primary focus is on producing parts of consequence — those essential for operating platforms and weapon systems. These may include spare parts, temporary replacements for repairing battle damage, obsolete or legacy components, as well as tooling and parts needed in small quantities.

Examples of the few known cases of AM-produced metal parts in the Ukrainian theatre are hinges for the decades-old Australian version of the M113 armoured personnel carrier (APC) 3D-printed by the UAF, as well as tooling that allowed Ukrainian forces to handle American material measured in inches (GlobalData, 2024). Reports further documented the production of parts that undergo significant wear, such as firing pins for the M777 howitzers (Harper, 2023). While it is highly likely that other parts for MRO are also printed, there is no public information about exactly which parts, though the situation is continuously evolving. Some reports detail the delivery of 3D printers to the frontline for the production of parts needed to repair armoured platforms and various older systems, such as SPEE3D's Cold Spray AM machine. The Australian military already tested this system to produce parts for its M113 APC as early as 2021 (SPEE3D, 2023). Moreover, shipments of 3D printers to assist with the repair of CAESAR artillery systems have been reported (Defence Industry Europe, 2024). In as early as 2018, a study analysed the potential of AM to produce replacement parts for howitzers (specifically the M109A6 Paladin). The findings indicated that a single direct metal laser sintering printer could supply sufficient replacement parts with a maximum size of 1638.7 cm^3 (equivalent to a volume of approximately 1.64 L) for one mechanised artillery battery (T. A. Moore et al., 2018). While the study simulated the conditions and supply chains for extensive combat situations, *the use and shipment of 3D printers in the Ukrainian theatre could be viewed as a partial achievement of the posited increased effectiveness of military logistics through AM. Experiences and lessons learned from Ukraine regarding the repair of vehicles seem to be replicated by other armies*, with the US commissioning 3YOURMIND and Philips Corp to identify which parts of the US version M113 APC could be manufactured with AM, and the British Army turning to metal AM to generate parts for the Titan and Trojan periscope system (Keane, 2023; Kremenetsky, 2024).

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2 William LaPlante, previous U.S. Under Secretary of Defense for Acquisition and Sustainment, quoted in Harper (2023).

These examples show that AM can, to a certain extent, be used to uphold military readiness and serve as a substitute in situations when a surge of demand overwhelms supply. Without comparative studies from the field, the impact of the entire operation, including design, file sharing, overcoming interoperability issues, training of soldiers and engineers, production, post-processing, and distribution, cannot be accurately assessed. Further, it has to be considered – and this applies to all in situ print operations – that item size is limited, ergo system integrity can only be upheld with AM when the item that needs replacing does not exceed the printer size. *Additive manufacturing should be viewed as a tactical logistical support mechanism but not a replacement for conventional supply chains.*

3.3.2 MOBILE 3D-PRINTING FACTORIES

The AM industry has developed solutions that are partially tailored to applications in the field, as they can be transported, are easy to set up, and contain the necessary hardware to complete all process steps, including post-processing, with a machine tool or through thermal treatment. Such solutions are often – but not exclusively – container-based, with some using WAAM, such as Rheinmetall's "Mobile Smart Factory" or Fraunhofer IAPT's "Additive Mobile Factory", or other AM processes, such as Australian SPEE3D's "Expeditionary Manufacturing Unit" which produces metal parts via cold spray AM. The German firm Xerion also offers a smaller concept called "Fusion Factory XS", which has been credited as the only sinter-based AM mobile system capable of processing metals and operating at sea (Ribeiro, 2024; see Figure 3).

Figure 3: Fusion Factory XS. Credit: Liska Suckau

The part sizes that can be produced in these units range from parts that fit in the “Fusion Factory XS” (size of sinter furnace working space: 80 x 150 x 70 mm) (XERION, 2025), to those with a diameter of up to Ø 700 x 450 mm (Rheinmetall, 2023) and Ø900 x 700 mm (SPEE3D, 2024) respectively. There has been no public discussion on the practicalities of these units, such as the extent to which calibration might be difficult, how files are exchanged with the OEM or any lessons learned from participation. On-demand and instantaneous access to mobile manufacturing is gaining traction, with one British army spokesperson, for example, describing it as “heralding a step change in deployable engineering capabilities for our forces deployed overseas” (Mackenzie, 2024). Ultimately, more transparent communication and data are needed to further substantiate statements like this.

3.3.3 MANUFACTURING ON BOARD OF SHIPS

One such use case for mobile 3D-printing solutions is on board military maritime platforms. *Several navies, including Australian, British, Chinese, Dutch, Finnish, French, German, Indian and US, have reportedly tested or already integrated AM.* Producing spare parts on board ships can be challenging due to environmental factors such as vibration, motion and temperature fluctuations. However, in situ production and repair are particularly valuable in the maritime domain, as downtime on land for MRO is costly with the vessel not being deployed (Ziółkowski & Dyl, 2020). Moreover, supplying spare parts to a vessel on an overseas mission that is potentially disabled and adrift due to a fault can be difficult, expensive and time-consuming. Additionally, AM could aid recycling efforts on board, by reusing material from plastic bottles for printing, for example. Lastly, vessels are in use for decades, making their upkeep a complex task, as OEMs may no longer manufacture spare parts. While there remains a substantial need for further research into the identification of parts for MRO, an analysis of economic feasibility for in situ printing, the creation of standards and qualifications is necessary, as is ensuring reliability and replicability. Existing studies already provide evidence of the utility of AM in enhancing the operational readiness of military ships (Garofalo et al., 2024; Hartig, 2023).

The US armed forces are increasingly interested in using metal AM to produce more parts for their new Columbia class nuclear submarines to overcome long lead times (Freedberg, 2024). Additionally, the French Navy has been testing DED printers made by Meltio, reportedly soon to be installed on the country’s aircraft carriers to produce metal components (Davies, 2024). The Royal Netherlands Navy appear to be the only organisation to have already systematically equipped all their ships with UltiMaker 3D printers (Chavan, 2024). These printers enable sailors on board to produce spare parts using various polymers and composite carbon fibres. One example of this is a boat antenna bracket, which was designed and tested on land before being added to a digital file library accessible to the crew.

One study (Hartig, 2023) analysed the use of AM on board several German Navy vessels, primarily illustrating the use of AM to print polymer parts with a Stratasys and different Prusa FDM printer. These parts were, for example, replacements for broken components that are only available commercially in combination with the entire assembly. The study further found that in the future, high-performance thermoplastic polymers could temporarily replace metal parts on ships when necessary (Hartig, 2023). *Overall, current examples of AM use on board ships suggest that the production* *of metal parts might be more realistic on land, whereas (high-performance) polymers can help support MRO on ships during deployment.* Additive manufacturing offers navies a new option for the self-manufacturing of (temporary) replacement parts, helping maintain the operational capacity of ships until the next land-based MRO (Hartig, 2023).

3.3.4 PRINTING IN SPACE

Additive manufacturing applications in space are motivated by the high financial and ecological costs of operating spacecraft. Shipping items from Earth to space is very costly, and it is often challenging or even impossible to react flexibly to material needs. The primary challenge is the microgravity environment, which results in hardware not functioning correctly or exhibiting different material behaviours, alongside other difficulties caused by vacuum, atomic oxygen and radiation (Ghidini et al., 2023). One approach to overcoming this is the use of granular material as a feedstock and hardware customised to deliver and process this material. The procedure was developed and patented by researchers from the University of Glasgow and field-tested in parabolic flight conducted by the European Space Agency (ESA) (University of Glasgow, 2025). While this process has not been tested on a space station, the ESA successfully 3D-printed metal parts on board the International Space Station for the first time in late summer 2024 (Figure 4), using a specially designed printer that melted stainless steel wire with a laser to generate layers (Airbus, 2024; ESA, 2024).

Figure 4: First 3D-printed metal parts on board the ISS, 2024. Copyright: ESA/NASA

Although the ESA is a civilian agency, it plans to apply its spacefaring capabilities to both military and civilian use cases, thus enabling dual-use in situ printing. The overarching aim of advancing manufacturing in space is to conserve resources and funds by using raw materials that are either already aboard the spaceship or on another location planet. The intention is for AM to achieve this vision of self-sufficiency by enabling the production of different parts using the same machine, ultimately facilitating longer deep space explorations or the construction of satellite components in space. Testing continues to allow the production of diverse materials in space, such as biomanufacturing for pharmaceutical products outside spacecraft and under lunar or planetary gravity (Reitz et al., 2021). The key remaining issues that will require further research include concerns about safety, the extra equipment needed for space manufacturing, the execution of post-processing in space, and the limited data to facilitate a better understanding of manufacturing under microgravity due to restricted testing options (Hoffmann & Elwany, 2023).

3.3.5 ONLY BUMPS IN THE ROAD? PRACTICAL CONSIDERATIONS AND ISSUES

Many AM applications are still in the development and testing phase and it is unclear whether they will ever be fully implemented. Additionally, certain practical issues and considerations shape the adoption of AM for MRO: safety, regulations and standards, interoperability, and expertise and knowledge.

Safety and security are paramount in a work environment and especially in military operations. Military technology, like technology in general, should not harm or injure the user or civilians, nor undermine the integrity of the operation. This implies that its effects must always be controllable. One way to ensure safety is for production and testing to adhere to standards, allowing for the qualification and subsequent integration of AM products. Not all 3D-printed products warrant a stringent testing regime (e.g. non-load-bearing parts, such as casings to cover an air vent). However, some items are critical, meaning that functional failure can lead to total incapacity of a system that could result in a catastrophic failure. Examples of such items are load-bearing parts in the aerospace sector that are systematically and rigorously tested to prevent failures. Compared to conventional manufacturing, there is less standardisation of AM processes in the civilian and military domains, often perceived as resulting in a lack of guidelines to address the specific requirements of military technology (Colorado et al., 2023). In Germany, however, *a variety of standards and regulations are available to the armed forces allowing for the certification of manufacturers, processes and products*. These include, for example, the "Class guideline, Additive manufacturing – qualification and certification process for materials and components" (DNVGL-CG-0197) and "Additive Manufacturing – Qualification principles – Qualifying machine operators of laser metal powder bed fusion machines and equipment used in aerospace applications" (ISO/ASTM 52942:2020). The scope and extent of protocols to certify AM-manufactured security technology can differ by domain (land, sea, air) or process and material used (e.g. metal vs polymers, DED vs FDM, etc.) and can be even more challenging for niche products.

This results in a complex certification landscape that makes it challenging for manufacturers to serialise new items, as testing and qualifications can be lengthy and costly. The current timeframe for product qualification of critical components in the aerospace industry, for example, is approximately five years. To mitigate uncertainties for both manufacturers of printers and end users of printers, efforts are underway to close existing gaps in standardisation and methodology. Within Europe, the

EDA is committed to developing these common standards, focusing on improving military logistics, interoperability and interchangeability (EDA, 2025).

Introducing digital technologies to military supply chains brings new vulnerabilities and challenges around safeguarding sensitive information and IP, challenging interoperability and interchangeability. File exchange, which is crucial for in situ printing, is one such vulnerable moment. Currently, individual producers appear to communicate directly with the respective armed forces. However, there is one project that aims to centralise the data exchange and communication and develop interoperability among the various armed forces. The NATO Support and Procurement Agency (NSPA) was tasked with the development of a digital platform allowing an exchange of digital files between armed forces and the industry, dubbed RAPID-e (Repository for Additively Manufactured Products in a Digital Environment). According to the NSPA, the system is being tested in Ukraine, but no information is available about its performance (NSPA, 2023).

3.3.6 LOOKING AHEAD: AM AS A MILITARY CAPABILITY AND THE RIGHT TO REPAIR

The ideal logistics scenario on the frontline would involve using the smallest number of manufacturing systems to produce the greatest variety of parts. This would mean OEMs providing digital designs that can be used with the military's chosen AM printer, rather than each company developing its own hardware and software solution to meet the specific demands of one platform.

To use AM for military logistics, personnel must be able to operate the machinery. Personnel on board navy vessels, for example, have limited time to carry out printing tasks on top of their regular duties. Broader integration with land-based institutions is necessary to ensure an efficient workflow (Hartig, 2023). Alongside actually manufacturing items, soldiers must undergo training to design parts, operate the 3D printers and post-process items, or, depending on how AM is to be implemented, even conduct all three processes. Besides the technical improvements, reports document that the design process can be beneficial to the soldiers themselves, as it fosters critical thinking and enhances engineering skills and morale (P., 2024a). *Efforts are underway to enhance the armed forces' capabilities by gaining and pooling technical expertise to perform as many tasks as possible in-house with AM, independent of the OEMs.*

Improving armed forces' technical capabilities makes them less dependent on spare parts suppliers or the OEMs of the systems. This goes hand in hand with the repairability of systems and the "right to repair", i.e. the right to dissemble, repair and reassemble systems in-house, independent of the OEM. During peacetime, purchasing contracts lay out the conditions for MRO by the troops themselves, contractors or the OEM tasked to do so. *Depending on the domain, the technical and legal possibilities to self-manufacture items differ; for example, strict qualification and licensing procedures in the air domain make it difficult (and costly) to guarantee the same manufacturing standards, which is crucial for accident liability, for example.* Items for the MRO of land vehicles are often standardised and not protected or patented. Therefore, 3D printing would not cause any further issues with the OEM under the conditions that the part can be reverse-engineered, the technical details are known and are not covered by a confidentiality clause in the purchasing contract. Armed forces currently conduct individual case assessments for each (potential) AM use case and application. These consider all the aforementioned points as well as whether a part is design protected, to what extent the purchasing contracts limit self-repair, and whether the part is a load-bearing component that requires qualification. Depending on the outcome of the assessment, the organisation in question decides whether parts should be self-manufactured or purchased. While self-manufacturing by the armed forces might be legally possible, outsourcing AM to third parties may infringe the OEM's trade secret rights and thus not be possible. *Embracing AM as a military capability in this context therefore means that repairability must be enabled by design, both technically, i.e. procured technology is designed so that MRO is independent of the OEM, and legally, i.e. purchasing contracts consider MRO the job of the armed forces, wherever possible.* Both manufacturers and armed forces are already working towards identifying an increasing number of parts that can be 3D printed and acquiring knowledge about the exact parameters for producing those parts with AM.

Releasing staff to attend AM training and to field printers across the different branches of the armed forces will take time and potentially financial resources. In the medium term, however, these efforts could pay off, potentially saving money and making the armed forces more responsive to material needs, provided they are accompanied by data collection and analysis of AM performance for the different applications presented above.

4. NON-STATE ACTORS' 3D PRINTING OF ARMAMENTS

Other actors outside the conventional state-led military domain, in contrast, have been using simpler AM methods to manufacture military technology. This is a user group that (depending on national legislation) undermines the state's monopoly on force, participates in conflicts as irregular combatants or supports them with material and/or moves within a legal grey zone with its use of additively manufactured military technology. Examples are the use of AM to address supply shortages faced by armed groups or as a tool by right-wing extremists. The unauthorised (according to national legislation) production of firearms has become synonymous with 3D printing, exemplifying how national security can also be affected by technological developments. This chapter details the manufacture of such small arms and light weapons (SALW) along with other items, and how these unconventional actors are using AM and the final products. While the actors in this section mostly rely on polymer-based and technically less complex fused deposition modelling processes, for example using material extrusion desktop printers, the global digitally networked community has created diverse applications with considerable sophistication. A closer look at these developments shows that they do not appear to match conventional military capabilities. What becomes clear, however, is that there is a community of actors capable of producing some capability outside an order that gives states the monopoly over those very capabilities.

Both the motives and context in which this group operates are quite diverse, ranging from lone wolf right-wing extremists to liberal gun enthusiasts and organised support networks (both outside and within armed conflicts) that manufacture and supply armed factions or groups, etc. Ukraine is mentioned several times in this section. Although the conflict there is interstate, there are active networks of volunteers in solidarity with Ukraine that design and manufacture items used by the UAF at the frontline. Within the context of Ukraine – and this extends to other cases – this section also addresses unconventional supply chains, as they deviate from the conventional military domain.

4.1 THE TECHNOLOGY OF 3D-PRINTED FIREARMS

Since the creation of the first functional 3D-printed gun – the "Liberator" – in 2013, additive manufacturing has become infamous for its role in the proliferation of "ghost guns" or untraceable weapons. However, privately manufactured armaments and firearms predate the "Liberator". In fact, according to police statistics, converted firearms that fall under this category, while not necessarily classified as "ghost guns", represent the most prevalent type of illicitly manufactured firearms within the EU (Schroeder et al., 2023). *With 3D printing, however, a new avenue to produce such illicit firearms or unauthorised armaments has become available and police seizures are increasing.*

Self-made SALW encompass a wide variety of different types, designs and manufacturing processes and it is impossible within the scope of this report to review them all. Generally, 3D-printed firearms can be categorised into three types: fully 3D-printed firearms, hybrid 3D-printed firearms and "parts kit completions" (Hays et al., 2023). The first entails all designs and applications built without any non-printed pressure-bearing items. These would only use certain small non-printed parts, as there is no known example of a functioning firearm produced entirely with 3D printing[3] (Hays et al., 2023). While most items in this category can only be used for a short period or to fire a limited number of shots, hybrid 3D-printed firearms have been found to approximate conventionally manufactured weapons in their performance (Veilleux-Lepage, 2021). This second category comprises firearms that utilise some metal parts, often in the form of a barrel, to optimise their performance. A submachine gun from this category is the best-known example, i.e. the "FGC-9" ("Fuck Gun Control – 9 mm") that has been sighted in the hands of rebels fighting the military junta in Myanmar, with Northern Irish paramilitaries, in several police seizures worldwide and across online fora further developing and improving the design (Dearden & Gibbson-Neff, 2024). A recently released new model – Urutau –requires no regulated items besides a thick-wall hydraulic pipe that functions as the barrel, and the manufacturing process has been optimised and well-documented to reduce the complexity of production and assembly. Previous designs were partially dependent on gun-related parts, such as the AR-15 fire control group springs, and required more complex metal processing (Veilleux-Lepage & Füredi, 2025). The last category, parts kit completion, is the largest of the three and comprises self-made firearms built with a mix of 3D-printed parts and conventional firearm parts, which are often – depending on national gun laws – regulated parts that can be purchased in kits (Hays et al., 2023).

The community involved in developing and enhancing designs is heterogeneous, partially influenced by national legislation, comprising various actors and generally distributed globally with diverse motives. The movement is, however, concentrated in the United States, where hobbyists, in particular, invent and develop 3D-printed armaments for fun. Alongside these hobbyists, other glob-

3 Even the "Liberator" had one small non-printed part

ally connected entities engage in manufacturing for criminal purposes, such as illicit trade or other criminal acts. The designs and build files are almost entirely accessible online to groups and individual actors alike. The belief in the individual right to carry and own firearms is regarded as a unifying constant across the otherwise politically diverse community (Basra, 2024; Hays et al., 2023).

4.2 OTHER SELF-MADE 3D-PRINTED ITEMS FOR COMBAT

Besides SALW, other security-relevant items can also be printed. These range from ammunition and accessories for SALW, such as magazines or thermal sights, to items used in trench warfare, including periscopes, modified ammunitions, weaponisable tools or parts of improvised explosive devices. And even this list is not exhaustive, and new use cases are continuously developed. Tests indicate that ammunition made with AM from polylactic acid (a commonly used thermoplastic polymer) – excluding the explosive – has the potential to be fully functional (Bisić & Pandžić, 2024). In current theatres of war, including Ukraine, 3D-printed items, often designed and produced by volunteers outside conventional supply chains, have become a characteristic feature (Dass, 2024b). One of the most documented and perhaps frequently used 3D-printed items in Ukraine are fins or sabots that can be attached to grenades or other explosives delivered by small drones and dropped on a target. With the proliferation of small drones, designs for these vehicles have also been developed that rely on 3D-printed parts. For example, in Myanmar, the "Liberator" drone[4] is constructed around a fibreglass-reinforced frame made with AM (Dass, 2024b).

The printers used to manufacture these items are desktop printers, primarily those using material extrusion, which layer various polymers to create the parts. Various brands of printer have been used for printing armaments and other materials, such as FDM printers from Czech company Prusa as well as the Chinese firms Creality and Bambu Lab. Various other companies also manufacture desktop 3D printers, and the quality of these machines, available from approximately €200, continues to improve.

4.3 ARMED GROUPS AND RIGHT-WING TERRORISTS

To fully understand 3D printing of armaments, it is essential not to understate the importance of the ideology attached to it. Additive manufacturing allowed easier and cheaper production of firearms compared to other DIY approaches, which was a significant improvement and, therefore, attracted gun enthusiasts and people who believe in the right to bear arms (Veilleux-Lepage, 2024). While the community as a whole cannot be categorised as extremist or prone to violence, the fact that AM is seen as a means of warfighting is evident in the international support of armed groups and militaries. For instance, the designers of the Urutau published a manifesto alongside the technical files, which, apart from providing guidance on evading detection by authorities, stated that their model was specifically developed to address unique challenges in fighting and guerrilla warfare (Veilleux-Lepage &

4 While the first 3D-printed firearm is also called the "Liberator", the drone of the same name is an entirely different device.

Füredi, 2025). Efforts by the forces fighting the military in Myanmar to use 3D printing are matched by an active online community, which, much like in Ukraine, provides assistance across borders in developing designs and hardware, such as printers and filaments (Füredi, 2023). It remains unclear to what extent 3D-printed firearms serve as fully-fledged substitutes for conventional arms, as reports indicate that 3D-printed guns were initially used to address a supply shortage until channels for procuring conventional firearms were established (Wesdorp, 2023). This tangible manifestation of international solidarity — although not uncommon in conflicts — further illustrates the diminishing distance between civilians and hostilities in warfare, a trend fostered by digital technologies that are transforming and defining contemporary armed conflicts (Ford & Hoskins, 2022).

At the same time, 3D printing of homemade firearms has, to some extent, become a symbol for far-right extremists around the world fulfilling their violent fantasies with self-made firearms. Other terrorist groups, such as jihadists, have shown little interest in 3D-printed firearms, though this, too, might be changing (Basra, 2022; Dass, 2024a, 2025). A recent study investigated the motivation of right-wing extremists through crime script analysis and found four motives in relation to the production or procurement of 3D-printed firearms. First, there were ideological motives, often linked to right-wing libertarianism, an anti-government stance and the symbolism associated with the use of 3D-printed, self-made firearms. Second, 3D-printed guns have been used or are planned to be used as a supplement to conventional armaments. Third, firearms were self-made because conventional firearms were not accessible. Lastly, selling 3D-printed firearms has become a way of earning money (Veilleux-Lepage, 2024).

Printing a firearm is not a trivial undertaking, as quite some skill, experimentation and time is needed. *The increasing sophistication of models, their widespread availability on online platforms, and the ability to evade detection using unregulated, non-firearm components, combined with improved operational security and a rise in 3D-printed weapon seizures, is concerning.* Parts of the population that hold anti-democratic, antisemite, racist and xenophobic, misogynistic and sexist views can now arm themselves, even in places with stricter gun laws, like Germany, to enforce their views with gun violence. The first victims of those heinous terror attacks are and will continue to be those members of society who already experience violence on a daily basis simply because of their skin colour, gender, sexuality, etc. The potential increase of right-wing extremists using 3D-printed firearms will not be contained with technical means such as increased documentation, forensics and surveillance. The strong links to ideology show that this is not a technical problem but a societal one. While a good understanding of the communities that hold these extremist ideological views is crucial, other mechanisms than surveillance must be found to ensure security for all.

5. CONCLUSION

This report provides a technical overview of AM in the military technology sector. Reviewing a technology always includes caveats, particularly when exploring something with numerous categories, use cases and varieties. The aim here is to provide the reader with an understanding of additive manufacturing and the factors shaping the sociotechnical environment in which it is employed.

Additive manufacturing is a technology that has impacted various sectors and stakeholders, with some describing it as a revolutionary advancement. Given the wide range of available process categories, it often seems that anything could be created with AM. However, the reality is more complex, particularly in an industrial context where factors such as economic efficiency and viability greatly influence the decision to adopt new technology. Additionally, significant effort is required to develop processes that achieve reliable and replicable outcomes, especially considering the novelty of AM which demands the resolution of the many unknowns in materials science to achieve such results. Market figures indicate that there has been a slowdown in sales of high-tech printers, reinforcing a more realistic understanding of AM as a technology that will serve as an additional option for highly specialised manufacturing processes but will not replace conventional manufacturing (P., 2025a). It further demonstrates that the market moves away from a hype, which will lead to adjusted expectations more aligned with de facto deliverables.

Based on current examples and use cases, the assertion that additive manufacturing as key contributor to military capability cannot be substantiated, as the majority of items continue to be manufactured with conventional manufacturing processes. Considering the production volume for some items, such as standardised ammunition, mass production with conventional processes is more efficient in leveraging economies of scale. However, there is evidence of increasing use of AM to produce military technology, although this is still in the early stages. The extent to which this type of manufacturing contributes to final products cannot be determined based on the public information available. While companies list AM in their portfolio of tools for producing military items, particularly for platforms across various domains, very few final products appear to be serialised due to a variety of reasons. This shows AM's significance for signalling technological edge, though, based on public data, it is difficult to verify its utility.

Nevertheless, as a military capability in the conventional military domain, AM is used for on-demand and in situ production of crucial parts and other components needed for MRO. Here, further progress can be observed, as machines and operations are being tested across different domains. Many armed forces have shown an interest in using AM to increase their responsiveness, resilience and readiness, and the use of AM for MRO in Ukraine has further confirmed its utility in this area. More transparency and data is needed to better understand and assess its potential and scope. Especially if AM is to be adopted as a standalone capability beyond the testing phase and not just as a tool, more than mere technological adoption and ingenuity are required. Successful military innovation also requires the institutional capability to adopt a new technology. This means organisational innovation, for instance by integrating AM as a mobile logistical capability for in situ MRO with the focus shifting towards the "right to repair", along with all the implications and demands of institutionalising such changes. This is a prerequisite for actually improving troops' resilience in the mid-term.

Various actors outside the military-industrial complex have adopted AM to manufacture military technology. This is generally not based on the use of high-tech industrial printers, arising instead from the diffusion of low-tech AM printers. A wide array of applications is now available that enables actors to acquire and use military capability. These actors are highly heterogeneous making it difficult to draw any general conclusions about them as their technical capabilities and more importantly intent strongly depend on the context of operation. A better understanding of how radicalisation processes interact with AM would support efforts to mitigate the risks deriving from radical actors within this community.

Overall, a closer examination of AM reveals a vast and complex technology that does indeed enable significant and impressive technological advancements. However, it also illustrates the challenges of implementing new technologies and, even more so, translating these advances into military capability. In terms of governing such capability, various approaches will be necessary to accommodate the different stakeholders. More specifically, national administrations have to access to what extent the export of AM should be controlled in a similar way to the existing regulation of manufacturing processes: as an additional manufacturing process for primary production, but also for the MRO of military technology and as the key technical component for establishing a new military capability. Additionally, more data and transparency are needed to close regulatory gaps for AM, in light of its dual-use character. The greatest challenge will be monitoring and regulating the actors producing military technology outside conventional frameworks. Not only does the technology and its use cases differ, but conventional and unconventional manufacturing of military technology also presents authorities with distinct threat potentials. While the former remains a concern for military effectiveness in the sphere of international security, the latter – based on known cases – poses a threat to domestic security. Moving forward, governance must take into account the nuances of the contexts in which various stakeholders operate in order to formulate regulations that encourage the further exploitation and research of AM, at the same time ensuring safe use for all.

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ADDITIVE MANUFACTURING IN THE MILITARY TECHNOLOGY SECTOR:

APPLICATION AND PROLIFERATION OF AN EMERGED TECHNOLOGY

Liska Suckau

Additive manufacturing, informally known as 3D printing, has created a range of new possibilities for both industry and consumers. Its potential for integration into the military domain, along with its role in the self-manufacture of armaments by non-state actors, has made the technology a focus point for discussion. This report presents a unique overview of the sociotechnical environment of additive manufacturing in the military sector. It discusses the relevant actors and showcases real-life applications to shed light on the factors influencing and limiting its use as a military capability.

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