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ADDITIVE MANUFACTURING IN THE MILITARY AND DEFENCE INDUSTRY

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Abstract: The use of additive manufacturing technologies is becoming more widespread. Obviously, such a new and innovative technology should also be used in the defence industry, despite the many strict safety criteria that have to be met in this field. The current paper presents, without being complete, some of the notable military applications where additive technologies are expected to become more significant in the near future.

Keywords: *military industries, additive manufacturing, 3D printing, defence*

1. INTRODUCTION

Thanks to the widespread use of additive manufacturing technologies, more and more areas are exploiting the benefits of the technology. Of course, for real components manufactured using this technology, intended for installation and long-term operation, it is particularly important to have a precise knowledge of the specificities of the technologies. It is also necessary to have the right raw materials at our disposal. Components intended for different applications have different requirements [9]. In many cases, e.g., for medical implants, it is not possible to check the component's ability to perform its function in advance at the final installation site and its load-bearing capacity must be verified in some way beforehand [1], [8], [10]. Additive manufacturing (AM), widely known as 3D printing, can be identified as a key enabling technology for improving industrial competitiveness by allowing fast, decentralised, and flexible production. Additive manufacturing is already being used in various industries, but the armed forces are still far from fully exploiting the potential of the technology. The expected growth of the additive manufacturing market could bring a number of benefits. These include reducing the cost of manufacturing tools and components, improving design, reducing time to the end user, and increasing technical and commercial competitiveness. In addition, 3D printing can have a significant impact on the maintenance of military equipment through the production of spare parts and equipment components. As air, land and naval defence systems have complex and specific basic structures, the customisation capability of AM and its on-site and on-demand properties are of particular interest to defence. Equally beneficial are weight reduction and increased component strength and durability, which were more difficult to achieve in traditional subtractive manufacturing processes due to processing and time constraints.

In addition, AM technologies can hold great potential for enhancing defence capabilities, such as logistical support to forces deployed in remote or enemy environments. The time between failures and recovery of platform availability, the transport and storage of significant quantities of spare parts can be reduced, with associated cost reductions, reducing the logistical footprint of the operation.

The "Additive Manufacturing Feasibility Study & Technology Demonstration" project successfully installed a 3D printing lab in Zaragoza (Spain) for the third European Advanced Airlift Tactics Training Course (EAATTC 17-3) in June 2017. The successful test flight of the AM lab was key to testing the feasibility of deploying the facilities by air. During the deployment, the AM-lab attracted great interest from multinational units participating in EAATTC 17-3. The deployment also highlighted the high interest and potential of AM technologies across all military branches (pilots, maintenance, technicians, and logistics support), with a high interest in the benefits that 3D printing could bring to their own specialisms. The conclusions drawn from this deployment will help inform the design and requirements of future 3D printing facilities. Awareness of the defence potential of AM is crucial. It will be equally important to create alignment between the materials R&D community and operational military personnel and to help the R&D community understand the capability needs of the defence side. There is also a need for education to make this technology effective and accessible to military users.

On the technological side, further work is expected on the use of additive manufacturing for lightweight ballistic defence. Other key challenges include process standardisation, certification of manufactured parts and legal aspects.

Filling these technological gaps could increase the logistical and operational agility of military forces and provide a decisive competitive advantage for defence in a rapidly changing technological and conflict environment [2].

Additive manufacturing is widely used in a number of sectors, including naval, aerospace and automotive. It is therefore not surprising that it is also increasingly being applied in the defence sector worldwide. In fact, the military 3D printing sector is expected to be worth $1.7 billion by 2027, which illustrates the importance of the technologies. Considering that the speed, lower weight, and lower costs are all priorities in the military, additive manufacturing will certainly have a role *(www.3dnatives.com)*.

2. Methodology

This paper is a literature review, in which I will show the potential for military applications of additive manufacturing technologies through some of the more well-known and implemented application examples. Of course, this is far from being complete due to the limitations of the scope, as there are many other applications of additive technologies in the military beyond the examples presented here.

3. THE USE OF ADDITIVE MANUFACTURING IN THE DEFENCE SECTOR

3.1. New 3D printer development

The US military is so convinced of the benefits of additive manufacturing that last year they announced they would even build the world's largest metal 3D printer. The US DEVCOM Army Ground Vehicle Systems Center is working with ASTRO America, Ingersoll Machine Tool, Siemens and MELD Manufacturing at Rock Island Arsenal – Joint Manufacturing and Technology Center to build the printer. The printer will be part of the Jointless Hull project, whose ultimate goal is to print monolithic (one-piece) hulls for combat vehicles. At the time of the announcement, it was estimated that the project would take about 14 months to complete, and the final printer will be capable of printing metal parts 30 feet long, 20 feet wide and 12 feet high *(www.3dnatives.com)*.

3.2. 3D printed runway for the US Air Force

Another application in the military and defence sector comes from ITAMCO (Indiana Technology and Manufacturing Companies), which has developed a runway for military expeditionary airfields using additive manufacturing. These runway mats are an essential component of Expeditionary Airfields (EAFs). Their function is to be implemented on soft ground surfaces to allow military aircraft to land and take off. Previously, a portable runway made of aluminium planks was used, but as this became obsolete, the military had to find an innovative solution. The M290 3D printer from the German company EOS was used to create a much lighter and more durable model for the US Air Force's military equipment *(www.3Dnatives.com)*.

3.3. Military modules, innovative use of additive manufacturing in defence

With the aim of boosting the development of strong and robust 3D printed factory modules, ExOne has joined forces with several partners to realise this challenge. In particular, the Defence Logistics Agency (DLA) contract was valued at $1.6 million. The process used ExOne's Binderjet technology for military applications because its speed, material flexibility and ease of use make it best suited to the critical needs of the military. The 3D printer, designed solely for the military, is said to be capable of binder jetting more than 20 metals, ceramics, and other powder materials – plus its unique housing and other features are said to make it perfect for a military-grade product *(www.3Dnatives.com)*.

3.4. The US Navy is also taking advantage of additive manufacturing

Marines have discovered that 3D printing can be used to create innovative tools for maintaining their vehicles. In particular, the Marine Corps Systems Command, in collaboration with supply battalions and industry partners, has additively manufactured metal steering wheel removal tools, helping to solve a common problematic operation that often needs to be solved during naval vehicle service [3], [7]. With the benefits of reduced maintenance time and increased readiness, additive manufacturing is highly profitable, especially when considering that the actual waiting time for such component parts is about 25 days [4], [6], *(www.3Dnatives.com)*.

3.5. The additive manufacturing propeller demonstrates the progress made in the French defence sector

The prestigious French company Naval Group has been using 3D printing for several years to meet different needs. In 2021, thanks to additive manufacturing, more specifically the WAAM (Wire Arc Additive Manufacturing) process, Naval Group 3D printed a propeller. The propeller, consisting of five 200 kg blades, was installed on the minesweeper Andromeda. The teams behind the project explained that by using the technology, they drastically reduced manufacturing time and minimised the number of materials used [5].

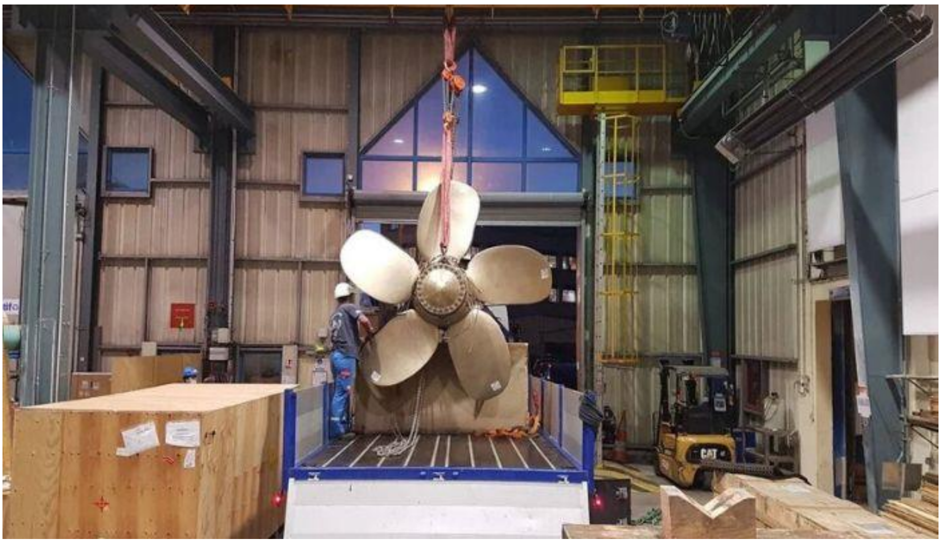

Figure 1. *3D printed boat propeller* (www.3dnatives.com)

4. CONCLUSIONS

It is also clear from the examples presented that the use of additive manufacturing technologies in the defence industry is still in its infancy. At the same time, however, it can be seen that it is being experimented with and its potential applications investigated in a number of areas. With its obvious advantages in terms of the ability to produce customised geometries, manufacturing flexibility, weight and cost reduction, logistical support and component supplies, it is evident that its application will be introduced in an increasing number of areas.

It is important to note that for military applications (priority safety criteria), specific requirements (technical and legal adequacy) have to be met in terms of processes and materials used. These take more time to meet, and their introduction may be slower than in the general market.

References

[1] Ficzere, P. (2018). Design Questions of the Individual Medical Implants. *Proceedings of 4th International Interdisciplinary 3D Conference: Engineering Section*, Pécsi Tudományegyetem, 2018. október 5–6.

[2] Lopez Vicente, P. (2017). Additive manufacturing in defence. *European defence matters*, Vol. 11, No. 14, https://issuu.com/europeandefenceagency/docs/edm-issue-14_web

[3] Alzyod, H. – Ficzere, P. (2022). Finite Element Modelling of Additive Manufacturing in Case of Metal Parts. *Periodica Polytechnica Transportation Engineering*, Vol. 50, No. 4, https://doi.org/10.3311/PPtr.19242.

[4] Ficzere, P. et al. (2013). Economical investigation of rapid prototyping. *International Journal for Traffic and Transport Engineering*, Vol. 3, No. 3. https://doi.org/10.7708/ijtte.2013.3(3).09.

[5] Ficzere, P. (2022). The Impact of the Positioning of Parts on the Variable Production Costs in the Case of Additive Manufacturing. *Periodica Polytechnica Transportation Engineering*, Vol. 50, No. 3, https://doi.org/10.3311/PPtr.15827.

[6] Ficzere, P. (2021). Effect of 3D printing direction on manufacturing costs of automotive parts. *International Journal for Traffic and Transport Engineering*, Vol. 11, No. 1, http://dx.doi.org/10.7708/ijtte.2021.11(1).05.

[7] Alzyod, H. – Ficzere, P. (2022). Using Finite Element Analysis in the 3D Printing of Metals. *Hungarian Journal of Industry and Chemistry*, Vol. 49, No. 2, https://doi.org/10.33927/hjic-2021-24.

[8] Ficzere, P. (2022). Research on and Practice of Additive Manufacturing Technologies. *Hungarian Journal of Industry and Chemistry*, Vol. 49, No. 2, https://doi.org/10.33927/hjic-2021-23.

[9] Ficzere, P. – Borbás, L. (2019). Experimental dynamical analysis of specimens' material properties manufactured by additive technologies. *Materials Today: Proceedings*, Vol. 12, No. 2, https://doi.org/10.1016/j.matpr.2019.03.135.

[10] Alkentar, R. – Mankovits, T. (2022). A Study on the Shape and Dimensional Accuracy of Additively Manufactured Titanium Lattice Structures for Orthopedic Purposes. *Periodica Polytechnica Mechanical Engineering*, Vol. 66, No. 4, https://doi.org/10.3311/PPme.20382.