3D Printing for Operational Support

military-Earth thinking notebook

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With a view to continuous improvement, the principle of optimising the maintenance in operational condition (MCO) of aeronautical, maritime and land equipment according to the triptych of cost, time and performance seems to be sustainable. Breaking away from existing logistics schemes, three-dimensional printing technologies could become an alternative or complementary solution to the more traditional ones contributing to this optimisation.

In 2013, during his State of the Union address, the President of the United States predicted that 3D printing would be one of the new technologies capable of boosting the innovation sector. He announced the launch of manufacturing centres, future partners in defence and energy.

In 2014, the US Navy is taking a 3D printer on board the aircraft carrier USS Essex and is organizing a maker faire for personnel called " Print the Fleet". 3D printing is then presented as a major issue with the aim of rethinking its supply chain.

With the desire for continuous improvement, it seems that the maintenance in operational condition (MCO) of aeronautical, maritime and land equipment should be optimized according to the triptych of cost, time and performance. Breaking away from existing logistics schemes, three-dimensional printing technologies could become an alternative or complementary solution to more traditional ones, contributing to this improvement.

Indeed, 3D printing is often presented as the beginning of the era of the third industrial revolution. In the economic sense, it is therefore what is known as an "innovation cluster"[1], just as the advent of the steam engine, the internet...

We will first describe what 3D printing is. Then, we will discuss the potential benefits of adopting this technology for OLS. Finally, we will end by listing the impacts of the

implementation of this technology from different angles that need to be considered.

3D printing

What's this all about?

Behind the generic term 3D printing or additive manufacturing, there are several processes with more or less identical purposes, which consist in manufacturing, via a specific printer, a defined object from a digital file by adding material, stratum by stratum.

This manufacturing process makes it possible, among other things, to no longer have to physically store on site the materials and parts necessary for the proper functioning of a company, but on the contrary to limit storage to a digital file.

It can represent a gain factor because the supply of materials or spare parts is then made as close as possible to the customer and on demand. Indeed, only the 3D file containing the technical characteristics of the product transits between its place of design and its place of production and use. This proximity manufacturing leads to a reduction in the circulation of raw materials between extraction and processing sites, often between distant countries. Moreover, once the finished product is finished, it is no longer necessary to package, palletise and ship it.

By modifying the logistics chains, the perception of savings is therefore noticeable, in terms of storage volume, fuel costs, etc., and the savings can be significant.

- Parts that can be produced in 3D printing

A printer can create different objects, even complex ones. Beyond plastic and metal, the most common materials used in this process, the variety of materials that can be used is important and makes it possible to obtain resistant products, sometimes even more resistant than traditionally manufactured models. Research and development in the sector is particularly active. It is now possible to print objects made of wood, cement or even multi-materials in a single piece.

- Cost price and performance of 3D printing

Depending on the application and the degree of complexity of the desired 3D printer, the price range is from €500 to €1,000,000. Everything is therefore based on the definition of requirements. Of course, to this entry cost must be added the cost of the raw material, on which manufacturers make high margins. By way of comparison, ABS plastic at $2/kg in bulk, once it has been processed into a powder or filament that meets the technical requirements, is priced between $35 and $80/kg. However, since it does not generate any waste, raw material purchases are reduced accordingly. Growth and competition in the sector are nevertheless tending to reduce tariffs.

Printing speed is linked to many criteria, the three main ones being the type of machine,

the material and the volume of the part to be produced. The three main criteria are the type of machine, the material and the volume of the workpiece to be produced, which means that it can last from an hour to days. However, the trend is towards ever more efficient models. Whereas in the beginning printers were mainly limited to the prototyping or even troubleshooting function, they are becoming competitive for small series production. The use of this type of production is booming in the aerospace and automotive industries. According to consultants from the Barkawi agency, Volkswagen's entire production should be handled by 3D printers by 2035.

The above figures are indicative. However, the number of large companies investing in these technologies suggests that they represent a real economic interest.

OFM and 3D printing

Maintaining military equipment in operational condition (MCO) is the set of preventive and curative maintenance actions carried out by the Ministry of Defence or by public or private manufacturers in order to maintain military equipment.[2]. It is worth asking what gains maintenance in operational condition could derive from the use of this technology.

- The necessary stock management

Before outlining the possible advantages of using 3D printing, it is appropriate to redefine the concept of stock management, which is one of the activities related to the OLM.

Stock is necessary for maintenance workers. Its adequacy to the demand is one of the success factors guaranteeing the fastest possible service to users. It is therefore intended to meet operational requirements according to the degree of commitment of the forces.

The cost of inventory management is characterised by an order placement cost, possibly a breakage cost and a cost of ownership. The latter is linked to the operation of the warehouse and the depreciation of items over time. Good inventory management results in the right quantity needed at the right time. If the stock is not large enough, it is called a shortage. On the other hand, a surplus is costly for the company.

The stock manager must therefore strive to guarantee optimum customer service (almost permanent availability of articles or parts offered for sale) while ensuring strict control of storage costs.

The art of the stock manager is therefore to maximize the service provided to the customer while minimizing the expenses incurred by the various costs. This is a difficult balance to find, which is partly solved by forecasting and planning software.

Warehousing issues[3] differ from one activity to another. As far as armies are concerned, the typology of the stockpile is linked to mostly specific equipment with a relatively long life cycle. This implies holding sufficient quantities of very dissimilar items.

- The place of 3D printing in the OLS

The use of 3D printing to replace all or part of the stock required by maintenance workers can therefore be very interesting and has a number of significant advantages.

First of all, as we pointed out earlier, the items would no longer be stored physically, but digitally.

In addition to the fact that sending the file of a coin is faster, easier and cheaper than sending the coin itself, one could easily update the coin file and always have the latest definition available.

A reduction in safety stocks would therefore be possible, as the technology would provide the flexibility to meet demand according to requirements. While reducing warehousing costs, this could ensure the availability of many BOMs. However, an exhaustive list of those likely to be concerned should be drawn up beforehand.

Routing would also be concerned since 3D printing would make it possible to dematerialize the transport of the spare part from the storage centre to the place of the request. For example, when setting up a force, it is necessary to build up an initial projection autonomy. In this case, 3D printing technology would free up some of the space dedicated to items from the initial autonomy and allow more flexibility for freight loading.

But also, on arrival in the theatre, it would make it easier to deal with the unexpected, especially as the conditions of access to the resource could be difficult.

3D printing would then be able, depending on the situation, to respond effectively to the maintainer's request in a shorter timeframe than the traditional timeframe. Simplifying the supply chain via on-site production is what the shipping company Maersk[4] is currently experimenting on its ships. The ultimate objective would be to avoid excessive equipment downtime and to ensure high technical operational availability (TOD).

Where could these printers be found in the Earth MCO, as part of the Earth MCO?

- In metropolitan France, within the regiments and equipment support base of the Land Industrial Maintenance Service (SMITer). If we consider that printing is equivalent to production, the choice would rather go to its maintenance units. However, it is also conceivable that it could be decided that this would be a new mission dedicated to supplyers. In this case, the location could be in the national spare parts warehouse of Moulins, or even in the companies and supply groups that hold the advanced stock.
- In operation, they could be installed at the level of the theatre-adapted maintenance subgroup (SGMAT), which is the unit in charge of the projected force's MCO. Finally, why not imagine the equipment of the future Griffon ELI[5] a 3D printer to enable them to extend their autonomy and their field of intervention as close as possible to the fighting forces?

Thanks to 3D printing, it is therefore possible to give flexibility to a supply chain. And, although not all parts can be copied, the benefits of this technology are likely to bring

significant cost and performance advantages: time savings through the speed and flexibility of the manufacturing process, reduced maintenance, shorter transport and storage times, etc.

As a result, it is now positioned as an interesting and complementary solution to inventory management.

The impact of the implementation of 3D printing

- Safety, manufacturer certification and liability

If it is possible to create parts in sufficient quantities, it is still necessary to ensure that the strength is in accordance with the original. Printing techniques are capable of producing parts that are as strong as or even stronger than those produced by current processes.

However, it is necessary for suppliers to authorise copying, firstly in terms of intellectual property because it is not a question of counterfeiting, and secondly in terms of safety, because it is essential that the object meets the manufacturer's standards in order to guarantee the protection of users.

While observing the above conditions, this limits, but does not rule out the legal risk. In the event of an accident or incident, who is responsible? Let us assume that one is authorised to reproduce the FAMAS play support and that it deteriorates during a shooting and causes damage. Who is at fault? The supplier who gave his approval or the manufacturer of the printer? And why not the producer, by default of quality control? On the subject of safety, no law or case law seems to have been passed or handed down.

Europe has launched the SASAM (SupportAction for Standardisation in Additive Manufacturing) project. The aim is to enact a standard on the standardisation of additive manufacturing equipment and materials in Europe. Contrary to the risk, which generates caution, the adoption of this standard would help to gain the confidence of market players.

User training

Once the decision has been made to embark on the path of 3D printing, it is important to ensure that the know-how of the personnel who will implement it is in line with the means to be exploited.

Where the traditional production system often requires special skills, 3D printing is more flexible and allows a greater variety of objects to be created with the same technology and equivalent skills. For printers using plastics and for which the CAD (computer-aided design) file is given, user training is simple. It does not require any special luggage, except at least some computer knowledge. For the production of metal parts, as printers are more complex, more specific training is required. On the other hand, when it is no longer a question of printing, but of designing, the profiles sought are senior technicians and engineers who know how to master a set of software specific to 3D.

The training offer, at all levels, is in full development. The CNAM (National Centre for Arts and Crafts), in partnership with the EVERYTEK association, is developing a training programme at all levels.[6] offers its students 3D training courses, the price of which varies from 750 to 3,000 € depending on the options chosen.

The learning component therefore remains affordable and can be envisaged in different ways such as outsourcing or creating a specialized course at the equipment school.

- Environmental impact

In 2015, investing in a project of rupture without taking into account the notion of sustainable development seems irrelevant. It is therefore approached from an economic, social and environmental perspective. The Ministry of Defence is totally in line with this logic, notably through the procurement directive, with, among other things, the desire to participate in the preservation of the environment.

So what consequences does 3D printing have on the environment?

The detractors will oppose it to be energy consuming, to use materials derived from oil such as ABS (acrylonitrile butadiene styrene), and resins / powders qualified as polluting. Production sites would also release fine particles that are harmful to health.

Proponents argue that the consumption of raw materials should be kept to a minimum, and that this would lead to a reduction in waste of up to 40% in the case of metal processing. Although ABS is a petroleum derivative, it has the advantage of being infinitely recyclable, and some polymers such as PLA (Polylactic acid frommaize) are fully biodegradable.

The pattern of production as close as possible to the customer and at the right demand can be seen as a positive externality for the environment. The resulting reduction in transport demand leads to a significant reduction in tons of CO2 emissions.

Despite the lack of precise figures, however, it seems that the ecological balance sheet is rather positive.

3D printing seems to be a technique that can be useful in optimising the ECO by the complementarity it can bring to traditional stock management and, more broadly, to the functioning of its supply chain.

The use of 3D printing can also be seen as part of the reactive adaptation process. Indeed, its vocation is not necessarily that of copying what already exists. On the contrary, it is also approached from a creative point of view by allowing the valorisation of innovative ideas. In 2012, the American army deployed a "Rapid Equipping Force" in Afghanistan. This is a 3D mobilelaboratory fitted out in a 20-foot container. Its purpose is to retrieve and process soldiers' feedback as soon as possible to avoid the loss of user information.

Within defence, other perspectives are still possible, such as for the health service or the police station. In the United States, various programmes are underway in the medical field

with bio-printing of synthetic skin, research conducted by AFIRM (Armed Forces of Regenerative Medicine), in the food field with printing of rations, research conducted by the NSRDEC (U.S. Army Natick Soldier Research, Development andEngineering Center).

If armies decided to optimise maintenance by installing 3D printing as close as possible to the forces, the problem of the concept of use would necessarily arise. Only in-depth studies would be likely to determine whether a change would be advisable and in what timeframe.

Is the 3D printing revolution under way? In view of the many developments that are taking place, it seems that the answer is yes. Its application to the maintenance of military equipment, both in metropolitan France and in operations, seems promising. Studies in this field must be carried out in order to clarify its scope and remove uncertainties.

1] Joseph Schumpeter, an Austrian economist of the mid-20th century, known for his theories on economic fluctuations, creative destruction and innovation.

2] Report of the Court of Auditors, "The maintenance of military equipment in operational condition - September 2014".

3] Robert Guiheneuf (1899-1986) is a French worker and writer. "Remarques sur la gestion des stocks dans l'entreprise", Revue économique, volume 7, n°1, 1956. pp. 68-91

4] www.maersk.com: 3D printing could revolutionize the supply chain for Maersk tankers.

5] The Griffon is the name given to the future multi-role armoured vehicle (MRMV). The name ELI (Light Intervention Element) refers to the version equipped to meet maintenance requirements.

[6] EVERYTEK (all technologies) is an association which proposes the first French professional training entirely dedicated to 3D printing.

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