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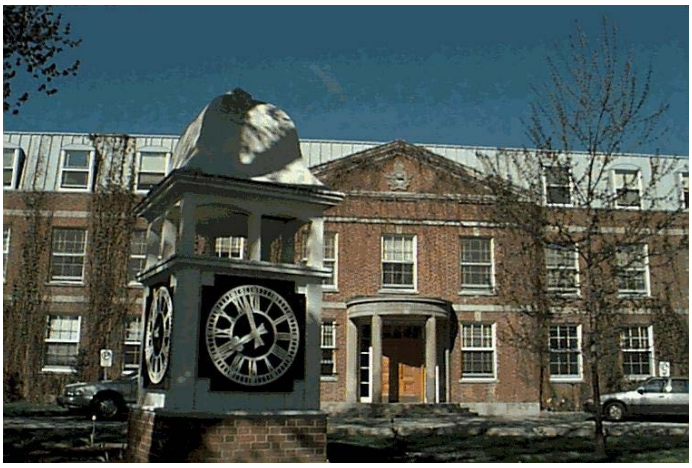

REVAMPING THE SUPPLY CHAIN WITH 3D PRINTING

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JCSP 45

Service Paper

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REVAMPING THE SUPPLY CHAIN WITH 3D PRINTING

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REVAMPING THE SUPPLY WITH 3D PRINTING

AIM

1. The aim of this service paper is to present a brief analysis to Canadian Joint Operations Command J-4 of how the 3D printing technology is affecting the industry and its supply chain. An effort will be put towards a potential application of this technology by the Canadian Armed Forces (CAF) and present impacts on its supply system. To understand the application of this technology within CAF, a description of the current supply chain system and its issues will be presented, then subsequently a discussion on the 3D printing technology.

INTRODUCTION

Current CAF Supply system in a nutshell

2. The Department of National Defence (DND), the biggest department of Government of Canada (GoC), has an estimated of material worth $9.8 billion.[1] The system is designed by three different layers of line-support: National CAF Depots (3rd line), CAF Bases (2nd line), and CAF Units (1st line). At each of these levels, an allocation of resources has been determined based on estimation of needs. The application is done through an automated supply system that has specific minimum and maximum levels set for every item.[2] For example, an item "X" has a minimum set at two in inventory and a maximum of five. Once the stockholding of this line-support reaches the minimum, an automatic order to replenish to the maximum set is pushed by the supply system.

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[1]Department of National Defence. *Audit of Warehouse Management* (Ottawa: Chief Review Services, 7050-59 (CRS), January 2014), 7.

[2]Department of National Defence, *Evaluation of the Land Equipment Program* (Ottawa: Assistant Deputy Minister (Review Services), 1258-211 ADM(RS), June 2015), 32.

Critical issues with our CAF supply system

3. Our supply system, as designed, is considered effective in theory. The reality is different, because a myriad of factors is affecting its performance, and it is costly to the organization at large. As presented before, the CAF supply system has a static approach: Minimum and Maximum set. The system does not consider usage over time, a human intervention is needed. For example, an item X could have been used once in a while over time and because the line-support level has reached it minimum, the system will automatically try to resupply its maximum set, even though the usage of part X was barely needed over time. We can conclude the management of this specific item is not efficient, implying non-necessary costs. As per the Auditor General, we, on behalf of GoC, are required to use our assets to their fullest potential to ensure proper resource allocations, protecting tax-payers money.[3] Furthermore, an official report from the Assistant Deputy Minister (Review Services) has analyzed the performance of the Land Equipment Program over a period of 46-months from 2010-2014 and its findings were alarming. To try to sustain the demand from first-line units, the procurement authorities, proceeded with buying activities to address the deficiencies of the supply system. Therefore the analysis reported a monthly purchase average of $18 million spent on procurement of items above what was initially allocated in the system. There are multiple reasons for this significant spending, but the main reasons were that repairable items were not sent for repair, level of holdings were inaccurate, and items not allocated properly to the right line-support entities as shown by a dormant stock analysis.[4] As a result, CAF have been accumulating material at all line-support

[3]Auditor General of Canada, *2018 Spring Reports of the Auditor General of Canada to the Parliament of Canada* (Ottawa: Auditor General of Canada, Report 2 – Disposing of Government Surplus Goods and Equipment, 2017), 11.

[4]Department of National Defence, *Evaluation of the Land Equipment Program* (Ottawa: Assistant Deputy Minister (Review Services), 1258-211 ADM(RS), June 2015), 32-33.

levels, requiring more storage space.[5] An Inventory Management Initiative has been created to help all line-support levels to address the activities not executed and an estimate of $162 million in gain is anticipated.[6]

DISCUSSION

3D printing explained

4. The CAF supply system presents weaknesses that 3D printing could address partially and improve the readiness of our first-line units. 3D printing is a process to create an object like a common printer, but using a three-dimensional model.[7] Its fine application of successive layers permit the printing process to create an item as a whole, without connections added compared to the usual manufacturing process. The material loss is minimal and its usage is optimized.[8] Companies are considering this solution as it often minimizes the down-time of broken machinery waiting for a traditional service-provider to manufacture a new part.[9] As the technology evolves, new materials are added to the list. The most popular are plastics, stainless steel, bronze, gold, nickel steel, aluminum, titanium, carbon fiber, and ceramics.[10]

Reliability of 3D printed products

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[5]Department of National Defence. *Audit of Warehouse Management* (Ottawa: Chief Review Services, 7050-59 (CRS), January 2014), 6.

[6]Department of National Defence, *2017 Defence Renewal Annual Report: Realizing the opportunity* (Ottawa: Defence Renewal Team, DGM-17514-NQX, 2017), 7.

[7]Helen Rogers and Norbert Baricz, "3D printing services: classification, supply chain implications and research agenda," *International Journal of Physical Distribution & Logistics Management* 46, no. 10 (2016): 887.

[8]Zhen Chen, "Research on the Impact of 3D Printing on the International Supply Chain," *Advances in Materials Science and Engineering* Article ID 4173873, (2016): 4.

[9]Alan S. Brown, "Chain Reaction: Why additive manufacturing is about to transform the supply chain," *Engineering the magazine of ASME Special Report Mechanical engineering*, (October 2018): 4.

[10]K.R. Gager, "Just Do it…Yourself: Implementing 3D Printing in a Deployed Environment" (Air Command and Staff College Course Paper, Maxwell Air Force Base, 2017), 10.

5. A 3D printed object presents an integrity that is defying the traditional manufacturing. For example, an overall assembly could require multiple parts to be added to make a piece of machinery. We can imagine that if a 3D printer could produce the same piece of machinery as one part, there are fewer areas of weaknesses in the final product. Joints and welding required in traditional manufacturing are then avoided resulting in a better integrity of the object. The structure is then stronger and it has taken less amount of labor involved with fewer connections to make and seal.[11] As a tangible example about quality, the US Navy successfully tested a Marine MV-22 Osprey that flew with "flight critical" component built by a 3D printer.[12] That is impressing given the high standards of quality needed from the US aeronautics industry.

6. An attention to Quality Control (QC) in the production process with 3D printing is considered in development. Researchers are developing standards and parameters to improve QC that will ensure quality of a 3D printed product is superior to traditional manufacturing.[13]

Easy product tailoring with 3D printing

7. A direct potential benefit for the CAF would be an easier application of its own specifications to a product purchased off the shelf rather than requesting the manufacturer to modify the product as source. 3D printing can build these add-ons sought by the CAF. That means that the organization will not be tied anymore to traditional constraints imposed by production.[14] The CAF requirements are often adding significant cost and time to the production of the material the CAF is looking for.

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[11]*Ibid.*, 26.

[12]Sydney J. Freedberg Jr, "First Osprey Flight with Critical 3D Printed Part," *Breaking Defense* (3 August 2016), http//breakingdefense.com/2016/08/osprey-takes-flight-with-3d-printed-part/.

[13]Hoejin Kim, Yirong Lin, Tzu-Liang Bill Tseng, "Quality control in additive manufacturing," *Rapid Prototyping Journal* 24, no. 3 (2018): 646.

[14]Sebastien Mohr and Omera Khan, "3D Printing and Its Disruptive Impacts on Supply Chains of the Future," *Technology Innovation Management Review* 5, no. 11 (November 2015): 3.

8. Usage of 3D printers has another notable potential benefit for the CAF. The organization equipment purchase and training on it is based on the capacity to operate everywhere the CAF might need to be. For various reasons, our equipment and material mostly followed North American standards. With missions everywhere in the world, the supply chain has had issues to find proper parts locally where operating. The avenue of 3D printers could address these situations and permit the production of tools and parts directly on site, providing customization and flexibility to our supply chain.[15] The CAF would be independent of the location it is operating assuming it has the material and the proper 3D printer.

3D printing is more environmental-friendly than traditional manufacturing

9. Being environmental-friendly may not have too much traction into the military debate at first but it is a strong value pushed by the GoC with its organizations. The Department of National Defence is not an exception to that. The CAF spends countless resources to be above the level of compliance at our bases and everywhere it is operating. Therefore, if a technology permits the CAF to be even more environmental-friendly without a sacrifice to operations, then a consideration should be given. 3D printing has many attributes that are displaying a more environmental-friendly approach than traditional manufacturing. As discussed earlier, the source of material to produce an object comes as a brick of that same material. This promotes the possibility of recycling the materials to make the source.[16]

[15]Zhen Chen, "The Influence of 3D Printing on Global Container Multimodal Transport System," *Complexity* Article ID 7849670, (2017): 2.

[16]Sebastien Mohr and Omera Khan, "3D Printing and Its Disruptive Impacts on Supply Chains of the Future," *Technology Innovation Management Review* 5, no. 11 (November 2015): 2.

10. In addition to recycling the material, the 3D printing process by its layer applications and accuracy is producing less waste. Cuts and adjustments are significantly decreased. These effects are contributing to a greener environment and way of operating.[17]

11. Another environment-friendly effect would be coming from the fact that 3D printers could be deployed at any locations the CAF would like to use them. Producing at a location closer to the area where the object is needed means that the supply chain is reducing its global footprint, resulting in a reduction in carbon emissions.[18]

3D Printing provides savings in time and money

12. The CAF procurement strategy acquires often equipment and material that will be in use for the long haul. A common issue encountered with repairs is the manufacturers do not have the capacity or desire to produce the required part over time because the market has changed. Fundamentally, a manufacturer will develop only molds for parts after a significant need in production.[19] In some cases, the original manufacturer does not exist anymore. The 3D printing can provide some solutions to these issues. By using this technology, the CAF would be independent of the manufacturer and be able to produce itself these parts and tools that do not exist anymore.[20] In combination with recycling of raw material, it can be reused in the 3D printing process several times.[21] This will provide significant savings and save time to repair a broken part.

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[17]G.R. Janssen, J.J. Blankers, E.A. Moolenburgh, A.L. Posthumus, "TNO: The Impact of 3-D Printing on Supply Chain Management," The Hague, Netherlands (2014): TNO.

[18]I.J. Petrick, T.W. Simpson, "3D Printing Disrupts Manufacturing: How Economies of One Create New Rules of Competition," *Research-Technology Management* 56, no. 6: 12-16.

[19]Alan S. Brown, "Chain Reaction: Why additive manufacturing is about to transform the supply chain," *Engineering the magazine of ASME Special Report Mechanical engineering*, (October 2018): 4.

[20]*Ibid.*, 4.

[21]K.R. Gager, "Just Do it…Yourself: Implementing 3D Printing in a Deployed Environment" (Air Command and Staff College Course Paper, Maxwell Air Force Base, 2017), 8.

13. Another factor of time and savings that will reflect into the supply chain by the 3D printing is situated into the transportation of the produced objects. The technology, if used closer to the needs, will avoid the necessity to reach back to the National Depots or to a manufacturer. That reach back must be captured as it is reflecting into the transportation cost. If air transportation is needed, it adds a lot to the financial equation.[22] The military at large has also a large number of different items requiring particular transportation and packaging techniques.[23] Combined with the fact that aircraft loads are scrutinized to bring in theatre the right priorities of material and equipment, it could take some time to get the part, adding to the length of time to fix what is broken. The 3D printing could avoid these unnecessary delays by transportation and provide incredible savings.[24]

14. The usage of 3D printers will have a significant impact on inventory as well. The capacity of producing, as needed, will reduce overproduction and the necessity to bring amount of spares just in case.[25] Instead, the CAF supply chain would focus on bringing the raw material and produce equipment when needed.[26]

15. From a procurement and application perspectives, the best application of 3D printing would be to have the capability as close to the end of the supply chain as possible. The time of

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[22]K.R. Gager, "Just Do it…Yourself: Implementing 3D Printing in a Deployed Environment" (Air Command and Staff College Course Paper, Maxwell Air Force Base, 2017), 6.

[23]Sokri Abderrahmane, "Military supply chain flexibility measures," *Journal of Modelling in Management* 9, no.1 (March 2014): 79.

[24]Zhen Chen, "Research on the Impact of 3D Printing on the International Supply Chain," *Advances in Materials Science and Engineering* Article ID 4173873, (2016): 2.

[25]Sebastien Mohr and Omera Khan, "3D Printing and Its Disruptive Impacts on Supply Chains of the Future," *Technology Innovation Management Review* 5, no. 11 (November 2015): 2.

[26]Alan S. Brown, "Chain Reaction: Why additive manufacturing is about to transform the supply chain," *Engineering the magazine of ASME Special Report Mechanical engineering*, (October 2018): 5.

response and demand from customers would be better served.[27] The CAF supply chain could consider investing into 3D printers that produce items not too risky for its operations to get our personnel acquainted to the technology and assess the results. There are also a number of firms specialized into finding the appropriate 3D printing service provider depending of the equipment required.[28] This approach could be considered for items that are more specialized or requires advance technology to produce a certain item.

CONCLUSION

16. 3D printing has the potential to address many of our current CAF supply chain issues. As previously presented, the technology will affect the procurement strategy, the inventory needed, the transportation required to move the material and equipment, and it will provide significant savings. The 3D printing would provide a better responsiveness from the supply chain, decrease the issues related from the allocation of resources and avoid these costly procurement activities that are used to rectify a supply system that has significant discrepancies. The real gain will be felt at the first-line unit level by the improvement of readiness of their material and equipment, therefore enabling their capacity to fight.[29]

RECOMMENDATION

17. It is recommended to create a working group constituting a sample of the first-line, second-line and third line units within Canadian Joint Operations Command (CJOC) to discuss

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[27]Zhen Chen, "Research on the Impact of 3D Printing on the International Supply Chain," *Advances in Materials Science and Engineering* Article ID 4173873, (2016): 6.

[28]Helen Rogers and Norbert Baricz, "3D printing services: classification, supply chain implications and research agenda," *International Journal of Physical Distribution & Logistics Management* 46, no. 10 (2016): 887.

[29]L. Burns, F. Tseng and D. Berkowitz, "Global network analysis in a military supply chain: using a systems based approach to develop a next-generation end-to-end supply chain performance measurement and prediction system," *Proceedings of the 2010 Cambridge International Manufacturing Symposium, Cambridge, UK*, (23-24 September 2010), 12.

the possible acquisition of 3D printers and their impact on the CAF supply chain. A collaboration of Assistant Deputy Minister (Material) would also be ideal as it could impact their procurement strategy as well.

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