Rapid Prototyping Vehicle with Additive Manufacturing - Supporting Military Field Maintenance

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ABSTRACT

The potential of additive manufacturing (AM) to support military maintenance has been recognized in the armed forces around the world. The Australian Department of Defense (DoD) has published the research report: Advanced Materials and Manufacturing – Implications for Defense to 2040 (2018), which estimates that the development of materials and manufacturing methods will have a major impact on defense and national security in the coming decades. The United States Department of Defense - Additive Manufacturing Strategy (2021) assesses the revolutionary impact of digital manufacturing on defense and the industrial part of the defense. Both reports highlight the speed and flexibility of production as a driver of change (Burnett, et al., 2018, Joint Defense Manufacturing Council, 2021).

Additive Manufacturing - more commonly 3D printing - has emerged as a potential digital manufacturing method (Lemu, 2019). AM is based on digital specification, where a 3D printing machine is controlled, based on a digital three-dimensional model created on a computer (Gibson, et.al., 2015). Its advantage is the production in a non-industrial environment with almost no geometric constraints (Ituarte, et al., 2017). These features make AM of military interest.

The usual way is to divide maintenance into depot-level and field-level. Severely faulty systems are delivered to depot-level maintenance while fewer faulty systems are repaired by maintenance troops at the field-level. Typically, field-level maintenance contains smaller and faster repairs. (NATO, 2012) In a previous study, we made a simulation of supporting field maintenance with industrial AM. The study´s key result was that the production speed of industrial-level AM is not yet sufficient to effectively support the maintenance of a mechanized battalion. Therefore, we concluded that industrial-level AM should be placed at the depot level. (Rautio & Valtonen, 2022) To examine the usefulness of industrial AM at the depot level, we made a simulation of the production capacity of 3D-printed spare parts and the maintainability of systems (Valtonen;Rautio;& Lehtonen, 2022).

Since industrial-level AM is too slow for field-level maintenance, our interest in this study is focused on supporting field-level maintenance with non-industrial AM. The study aimed to find out how we could maintain the capability to support troops near them with AM. We decided to test the "Rapid Prototyping Vehicle" that had been identified as one potential solution.

As a result of the work of the expert group, we identified functionalities in the vehicle:

- the ability to classify possible spare parts suitable for 3D printing
- make computer-aided models (CAD) required for 3D printing
- ability to 3D print prototypes
- produce simple spare parts that do not require industrial-grade 3D printing
- manage the 3D printing supply chain for industrial 3D printing -external supplier

The research was carried out as an experimental study, where a printing vehicle was developed and built with three AM technologies. The “Rapid Prototyping Vehicle” was tested first in a controlled field test in the National Defence University. Then it was driven to EDA co-operative workshop “AM Village” to test functionalities in the field test with other EDA countries and AM industry. With the help of an experimental study, information was collected on the factors related to the management of the method and the skills needed to use AM in the movable facility.

Based on the preliminary results of the study "Rapid Prototyping Vehicle" can support field maintenance near troops. It enables easy portability, which allows it to support troops where the need is greatest at any time. The training of the vehicle's operators affects how well it can meet the requirements for part classification, CAD modeling, and 3D printing. The use of 3D-printed parts should be based on decisions about what kind of parts can be printed on which system. The decisions also provide the basis for when printing should be done outside

the "Rapid Prototyping Vehicle" - with industrial AM capability. Data transfer and data management allow managing this supply chain that binds different methods and materials.

KEYWORDS
Additive manufacturing, 3D printing, Rapid Prototyping, Maintenance

PREFERRED WORKING GROUP
Military Technology

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