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Additive manufacturing in offsite repair of consumer electronics

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Abstract

Spare parts for products that are at the end of their life cycles, but still under warranty, are logistically difficult because they are commonly not stored in the central warehouse. These uncommon spare parts occupy valuable space in smaller inventories and take a long time to be transported to the point of need, thus delaying the repair process. This paper proposes that storing the spare parts on a server and producing them with additive manufacturing (AM) on demand can shorten the repair cycle by simplifying the logistics. Introducing AM in the repair supply chain lowers the number of products that need to be reimbursed to the customer due to lengthy repairs, improves the repair statistics of the repair shops, and reduces the number of items that are held in stock. For this paper, the functionality of the concept was verified by reverse engineering a memory cover of a portable computer and laser sintering it from polyamide 12. The additively manufactured component fit well and the computer operated normally after the replacement. The current spare part supply chain model and models with AM machinery located at the repair shop, the centralized spare part provider, and the original equipment manufacturer were provided. The durations of the repair process in the models were compared by simulating two scenarios with the Monte Carlo method. As the biggest improvement, the model with the AM machine in the repair shop reduced the duration of the repair process from 14 days to three days. The result points to the conclusion that placing the machine as close to the need as possible is the best option, if there is enough demand. The spare parts currently compatible with AM are plastic components without strict surface roughness requirements, but more spare parts will become compatible with the development of AM.

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Keywords: Additive manufacturing; 3D printing; digital spare parts; supply network; Monte Carlo simulation

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1. Introduction

Outsourced offsite repair warranty, also known as carry-in warranty, is commonplace in consumer electronics and means that the product needs to be taken to companies specialized in warranty repairs appointed by the original equipment manufacturer (OEM), as opposed to onsite repair warranty, in which the technician repairs the defective device wherever the customer is located. (Taylor 2007; Prabhakar Murthy & Blischke 2006)

Nomenclature

AM	Additive manufacturing
OEM	Original equipment manufacturer
MSC	Maintenance service contract
SKU	Stock-keeping unit
TAT	Turnaround time

To maintain the level of speed and quality of the repair of their devices, OEMs have maintenance service contracts (MSC) in place with companies that take care of their warranty repairs, henceforth referred to as repair shops. The MSCs obligate the repair shops to perform a certain percentage of repairs in a limited amount of time. The duration of repair is measured with Turnaround Time (TAT), which starts when the device is registered at the repair shop and stops when the device leaves the repair shop. The amount of work days necessary to fulfill the MSC conditions is often tightly calculated to include the diagnostics, spare part delivery, repairs, and testing of the products. As such, offsite repairs are relatively rigid and well controlled processes. In return for the services, the OEMs provide the repair shops with spare parts and pay per repaired device or a lump sum for the services provided during a certain period. The spare part distribution is often handled by separate companies that acquire spare parts from the OEM and distribute them to several repair shops. (Kurvinen et al. 2016; Dometic 2016; Prabhakar Murthy & Jack 2014)

As the acceptable number of days in repair is tightly set, the repair shops face sanctions if too many of their repairs fall behind that number of days. For this reason, it is a significant problem when a repair shop receives a device that has entered its end-of-life but is still under warranty. These devices rarely have spare parts readily available in the central warehouse of the spare part distributors. The spare parts must be sourced from smaller warehouses or from the OEM resulting in potentially very long delivery times. The repair can also be delayed if a technician performs a misdiagnosis or orders the wrong part, in which case the waiting time can be extended twofold. Alternatively, the plastic in consumer electronics tends to become brittle with age and a part can break during the repair procedure through no fault of the technician. In these cases, the repercussions of an extended repair process are inflicted upon three parties: the repair shop faces sanctions because it cannot fulfill the performance level required by the MSC, the consumer must wait longer for their unit to be repaired, and the OEM suffers image loss. To aid in this issue, the spare parts that can cause delays in the repair process could be additively manufactured.

The use of additive manufacturing (AM) in supply chains has been researched extensively in recent years. It has been shown to offer radical advantages in flexibility, savings in inventory management, and shorter delivery times. (Holmström & Partanen 2014; Sasson & Johnson 2016; Oettmeier & Hofmann 2016; Gebler et al. 2014; Mellor et al. 2014; Chen 2016). As a subset of the implementation research, the use of AM in spare parts applications has been researched with favorable results (Liu et al. 2014; Khajavi et al. 2014). According to the research of Khajavi et al., the most promising way of using AM in spare parts is to store 3D files on a server and download them for use per need. The question of the location of the AM machine appears in many research papers. In the case of this study, the machine could be placed in the repair shop, the spare part provider warehouse, or in the OEM manufacturing network.

Using AM in an offsite warranty repair supply chain could minimize outliers and make the TAT in the repair process more uniform. The introduction of AM in the supply chain of the spare parts would potentially reduce the TAT of repairs from weeks to days in specific cases. Additionally, the spare parts provider would benefit from reduced warehousing and logistics costs because the number of stock-keeping units (SKUs) to keep in stock would be lowered. Moving spare parts to the cloud would also enable the spare part providers to get rid of spare parts that spend years in storage without demand.