Spare Parts on Demand: Converting Physical Inventories into Digital

Aris Syntetos, Dave Watson, and Mike Wilson

PARC Institute of Manufacturing, Logistics and Inventory

Table of Contents

PREVIEW

When the production of some equipment/product stops, companies are forced to rely on a ‘last time buy’ (i.e. a final purchased quantity of spare parts) to support the operation of the equipment/product under concern for the remainder of its lifetime. Making an accurate ‘last time buy’ decision is notoriously hard.

In such a context, there is increased interest in the potential of 3D printing spare parts (instead of batch manufacturing them), if and when needed, to lead to important financial and environmental gains. It is intuitively appealing to expect that a shift from physical to digital inventories will return a reduced stock investment and diminished risk of obsolescence. However, this has not been empirically established yet. This is the focus of some of our current work in PARC, i.e. to turn this speculation into a trustworthy conclusion.

We are working with an international Japanese manufacturer of cash machines to explore a range of relevant hypotheses. All investigations are conducted via the PARC Institute and its RemakerSpace: an incubator for innovation in 3DP and product life cycle extension.

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MOTIVATION

3D printing (3DP) offers an opportunity to approach inventory problems from a different perspective: costly inventory which is also susceptible to obsolescence is replaced by digital files for items to be printed if and when needed.

The ‘last time buy’ in particular (forecasting, and committing to, the number of spare parts we need to buy, before their production is stopped, to support the remaining life of some equipment) is a notoriously difficult problem to solve, statistically. But 3DP printing offers the opportunity to print spare parts on demand (SPoD) without the need to keep stock.

Beyond the obvious financial benefit, the implications in terms of environmental savings and reduced obsolescence (for expensive and very slow moving spares) can be immense. PARC Institute, via its RemakerSpace, has collaborated with Glory Global Solutions to explore such implications and turn the intuitively appealing concept of SPoD into operationalised suggestions and insights.

Organisation of this Report

The remainder of this report is organised as follows. First, we discuss the nature of spare parts and the commercial and environmental value of replacing physical with digital inventories (SPoD). Next, we discuss the last time buy problem and how and why it makes sense to approach it from a SPoD perspective. Finally, we consider the collaboration between PARC and Glory to substantiate the natural fit of SPoD for the last time buy problem.

SPARE PARTS ON DEMAND (SPOD)

Spare parts are a crucial part of a product's life-cycle. Whether the parts are required for breakdown repairs, planned or preventive maintenance or as upgrades to existing products, they are vital to ensure the continuity of that product. Spare parts have a whole set of logistic requirements such as time-definite criticality and forward stocking locations, and as such require specialist care and attention.

A spare parts network, whether controlled and procured centrally, regionally, or locally will undoubtedly have duplicate inventory and at the same time be carrying old or even obsolete stock. If we just take a typical spare parts life cycle, the part would be manufactured using traditional manufacturing techniques – casting, forging, machining, molding – whatever the process, and it would be typically subject to economic batch quantity rules; would then be shipped to destination, distribution centre or forward stocking location and then stored on racks or shelves in a warehouse until required or it has passed its useful life and is obsolete and then scrapped and written off.

The manufacturer in traditional manufacturing will set up production lines and cover the expense of set up downtime and production costs by stipulating a minimum batch quantity or production run, independent of the quantity actually required. The company needing the parts then have to cover the costs of transportation of the parts to their destination or destinations and then pay for storage of the parts until needed.

Every lean course or program will tell you that two wastes that should be eliminated across every supply chain are transportation and storage…so if we look at the spare parts network then we have the cost of manufacturing parts that we don't need, we have the transportation cost of products we don't need, we then have the cost of storing products we don't need and then run the risk of scrapping the part when it becomes obsolete. Whilst it may be necessary to do this to maintain service, this network is full of waste and expense….so how do we overcome this?

We manufacture the part to demand as and when the part is required at the location it is needed - Spare Parts on Demand (SPoD).

Additive Manufacturing (AM)

We might need to provide critical spare parts with uncertain demand, or support assets for many years with spare parts, and find that the supplier or tooling is no longer available. With Additive manufacturing (AM) we just need to store the design in a digital inventory. Once a breakdown occurs, then print the spare part locally, on-demand. AM gives us a manufacturing process that allows us to do exactly this as it enables us to cost-efficiently produce parts from a batch size of just one, with close to zero fixed costs as there is no tooling or minimum order quantities required.

When the spare parts are stored digitally this eliminates both storage and transportation costs. And as discussed earlier, storing parts physically can also lead to disposal costs, if and when the parts become obsolete, which then also contributes to an environmental impact. With AM in place, once a part is ordered, it can be sent to the most appropriate production partner and so produced where and when it is needed thus reducing environmental costs and improving resilience.

AM (and 3D Printing in particular) is not new, it has been around for decades. But it was not until the mid-2010s that it gained popularity, as manufacturing machine capability and material technology improved considerably, and the overall manufacturing product cost became more competitive for some products when manufactured using 3DP techniques. However, these products were limited to small batches, prototypes, or individual designs as competing with mass produced components was still not economically viable. However, currently, with even better technology, speed of manufacturing and the increased focus on environmental issues, 3DP of parts becomes more attractive.

LAST TIME BUY (ALL TIME BUY)

Manufacturers of equipment of any type are typically responsible for providing spare parts for these products during the entire service period. The length of this service period depends on the type of product, and varies from months to (many) years. Since the service period is typically (much) longer than the production period, the service department places a large 'final order' for spare parts at the moment the product is taken out of production. This final order is expected to suffice, with a sufficiently large probability, until all service obligations have ended.

Determining this final order is known as the last time buy, or all time buy, or spare parts procurement after the end-of-production problem. Regardless of how is called, it is a notoriously difficult one to solve with immense financial and environmental implications.*

The first model to calculate the final order size was introduced in 1980 and assumed exponentially decreasing demand during the end-of-life (EOL) phase. (The EOL phase is the final phase of the product life cycle and begins when the product is taken out of production and ends when all service contracts have expired.) From a forecasting perspective then, the task is to estimate the rate of exponential decline – which is easier said than done! Alternatively, life cycle forecasting models need to be considered, which are even harder to successfully deploy. From an inventory control perspective, and as already discussed, the traditional mechanism of spare parts acquisition is to place a large final order causing major holding costs and a high level of obsolescence risk.

Although some progress has been made in this area since the early 1980's, more remains to be done. However, i) the proliferation of the product range companies offer, ii) the ever decreasing life cycles and thus availability of pertinent data, and iii) the fact that the final orders are often committed to very early in the life cycle (certainly earlier than the time production stops) may considerably impede progress. This is the reason why both practitioners and researchers now turn their attention to SpoD.

*In order to reduce final orders, researchers and practitioners have considered recycling the obsolescent equipment as the source of spare parts. This strategy cannot only reduce such orders and make full use of the residual value of obsolescent equipment, but also reduce environmental pollution. So, final orders and reuse supply chain design could be jointly considered, though we do not pursue this issue any further here. However, we have conducted some work to that direction. Please see here.

CASE STUDY

3D printing is a good fit for a variety of industries including those with long-lasting machinery, where support via traditional mass production is difficult due to the low part quantities required. This applies to heavy machinery but is also the case across many other sectors.

The continued evolution in technologies, materials and software have enabled a growth of commercial use in 3DP in the recent past. With increased accuracy and quality, industries such as aerospace and medical have been steadily increasing their use of 3D printed products. Moving from just plastics into metal and ceramic printing alongside the newer developed materials such as PEEK are expanding the capabilities of printed parts, especially to support these more demanding industries.

3DP of parts may also, of course, present challenges; we need to carefully assess and understand our spare part inventories, including technical and economic factors such as materials, size and shape, demand frequency and predictability. The analysis may conclude that not every part is suitable for 3D printing and Printability Indices may be particularly helpful towards reaching such decisions.

This is what we have done with Glory Global Solutions.

Glory Global Solutions

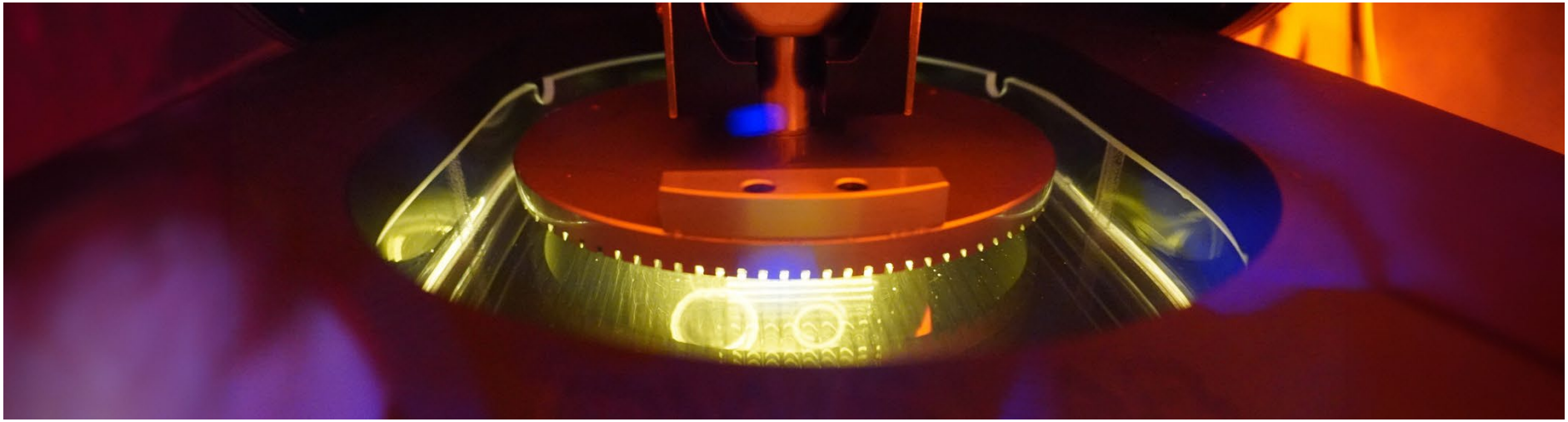
Recently, RemakerSpace secured its first commercial contract with Glory Global Solutions (an international leader in cash technology solutions) relating to 3D printing low volume production parts and spares on demand and the company's collaboration with the Centre has significantly improved their 'circularity'. The collaboration was facilitated by DSV Solutions, with whom Cardiff University runs the PARC Institute and RemakerSpace.

By using state of the art manufacturing techniques and methodologies the collaboration aims to introduce 3D printing as a viable production process.

Glory sought to investigate whether 3D printing low volume production parts and spares on demand could help the company reduce stock, lead times and tooling costs, whilst maintaining consistent build quality, which is the absolute priority. RemakerSpace's role was to identify materials, suitable components and processes that could help the company embed 3D printing to become a more sustainable business by reducing warehouse inventories, shipping costs and unnecessary waste

"Our association with RemakerSpace has significantly improved our understanding of the circular economy, and particularly 3D printing as a potential and realistic option for aproduction parts. Reduced global footprint and improved efficiencies with local manufacture, will help reduce our impact on the planet, and benefit our customers with express delivery of selected parts."

Mark Fifield, Group Quality Director,
Glory Global Solutions



CONCLUSION AND THE FUTURE

Currently, most parts are designed for subtractive (as opposed to additive) manufacturing processes holding back their ability to be easily printed by thin features and large overhangs. In the future, design for manufacture will have a newer meaning, rather than designing draft angles and ribs, focus will change to part orientation or nozzle and bed temperatures. Parts will shift their design for 3D Printing to be the main manufacturing process, requiring a range of new considerations to be factored in, 3D models created, and a large digital inventory needed. To achieve this, and indeed for AM to fulfil its true potential, a rethink of current supply chains will be needed.

Cardiff University and DSV jointly work in that direction; via the PARC Institute we currently strive to expand the existing knowledge base in this area and improve our Printability Index to discover component suitability for Additive Manufacturing as part of the circular supply chains.

DISCLAIMER

The background work of this report was supported by Cardiff University, UK. The report is intended for general information only; it is based upon a review of the available literature together with a case study investigation undertaken with Glory Global Solutions. Individuals or companies are advised to seek professional guidance regarding their specific needs and requirements prior to taking any actions resulting from anything contained in this report. Any such actions taken by individuals or companies are entirely at their own risk. Companies are also responsible for assuring themselves that they comply with all relevant laws and regulations, including those relating to intellectual property rights, data protection and competition laws or regulations. The images used in this document do not necessarily reflect the organisations entities taking part in this work.

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APPENDIX

The following list constitutes the background material covered to enable the writing of this report. Whilst it is not an exhaustive list that captures all the relevant literature, it is certainly representative of the research field. To enable an easier reading of this report we have opted for no embedded references. If you would like more guidance about the literature relevant to any of the areas covered in this report, please contact Aris Syntetos (**SyntetosA@cardiff.ac.uk**).

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THE AUTHORS

Aris Syntetos is Distinguished Research Professor of Decision Science and the DSV Chair of Manufacturing and Logistics at Cardiff Business School, Cardiff University.

Dave Watson is Director, Logistics Manufacturing Services (LMS) Commercial, at DSV.

Mike Wilson is Executive Vice President LATAM, Logistics Manufacturing Services, and Inventory Management Solutions at DSV, and Honorary Visiting Professor at Cardiff Business School.

PARC INSTITUTE

The PARC Institute is a joint University-Industry initiative that undertakes world-class research with impact in the fields of logistics and manufacturing operations management. The Institute bridges the gap between theory and practice in these areas for the benefit of a sustainable economy, environment and society. RemakerSpace is our incubator for innovation in 3D Printing, Remanufacturing and Repurposing.

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More about what we do and who we are may be found at **www.cardiff.ac.uk/parc**.