Supply chains are failing organizations and their clients, so why are we not rethinking them? 3D printing is bringing the promise of distributed manufacturing closer than ever

DISTRIBUTED MANUFACTURING

Disrupting supply chains with 3D Printing

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Failing supply chains, high infrastructure costs and consumer insistence on increasing customization are leading to growing demands for a change in the way we get products to users. Meanwhile digital manufacturing is maturing to focus increasingly on final parts production. Such an evolution makes way for these technologies to address supply chain failure by enabling distributed manufacturing.

Executive Summary

Companies face significant costs in their supply chains: inventory costs now make up $1.7trn, and transport costs represent 8.5% of GDP. Despite this cost, customers aren't happy: they face significant lead times, discontinued or even fake parts, and although their companies are trying to satisfy their customers' craving for more personalization, they are barely scratching the surface.

Defining Distributed Manufacturing

While the term 'distributed manufacturing' was previously used to refer to the management of distributed suppliers to a central assembly process, it is increasingly used to refer to the production of objects closer to the point of use

Digital manufacturing is beginning to address these challenges by transforming the way supply chains work. Companies and startups are engaging now to grasp the opportunities of a shifting supply change paradigm. They are improving production processes for final parts, which are still slow, complex and expensive. In addition, they are building new tools required for well-functioning, fully integrated digital supply chains, such as automated design file creation and optimization, non-destructive part certification, efficient production and reporting.

These leaders are building experiments designed to help them understand first-hand what this new supply chain paradigm means for them. They understand that although distributed manufacturing will only lead to production changes for a small part of their product line, it will transform their business. With these experiments they make physical spare parts a reality, enable customization by actual customers, or deploy new modeling techniques to unlock decades of old CAD data. In the process of interacting with an actual product, their customers and executives help them to:

1. Answer open questions about the market and viability,
2. Identify and build pragmatic solutions to problems, and
3. Learn of new business opportunities either in deploying those solutions for others or in building new tools and marketplaces.

Armed with this learning the companies are ready to benefit from the shift towards distributed manufacturing. Led by 3D printing, these technologies promise the ability to make products close or to the point of use.

Understanding Key Drivers

Supply chains need to evolve. Here's why.

High Logistics Costs

8.5% of US GDP is spent on logistics, though he true cost is even higher. Customers and end consumers are increasingly unwilling to buy products with long delivery timeframes, necessitating high inventory expenditures to keep stock on hand. US inventory expenditure exceeds $1.7 trillion, one third of which is retail inventory, resulting in a total cost of logistics and inventory in the United States of over 16% of GDP.

Inadequate Access to Genuine Replacement Parts

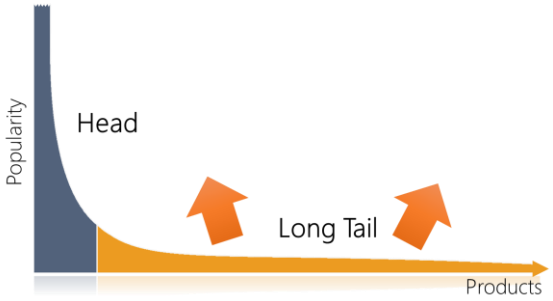
Machine downtime due to inaccessible parts is a high cost to business. In commercial aviation, the downtime cost is up to $1.2m per day for an Airbus A380. Non-productive time of deep-water rigs can cost $1.5m per day.

To compensate for this loss, companies and organizations stockpile spare parts. The Defense Logistics Agency alone spent $4.1bn on parts for contingencies between 2006-8, despite which they had inventory deficits of $1.5bn during the same period.

When the parts do arrive, there is fear that they are not genuine. In fact, fake spare parts are so pervasive that every commercial airline in the US is said to be affected. Fake parts were even found on Air Force One, and have been highlighted as a major problem in military equipment. In total, the International Chamber of Commerce estimates counterfeit goods globally to exceed $1.7 trillion by 2015. In the US alone, fake goods cost the fashion industry $12 annum.

Increasing Demand for Customization

In "Long Tail" Chris Anderson determines that the 20th century was about thousands of products selling millions of copies, while the 21st century is about millions of products selling thousands of units. As a society, consumption patterns are shifting away from the identical mass production paradigm introduced by Henry Ford. From 1997 to 2007, the number of car models on the market has more than doubled from 140 to 260. In a less capital-intensive industry like soft drinks, the number of brands has more than quadrupled from 20 to 90 in the same time period.



In order to adjust to this demand, supply chains are changing. Clothing manufacturers that used to introduce new clothes every season now do so frequently throughout the year. H&M and Zara famously deliver new lines of clothes every 4-6 weeks and offer 10,000 new products every year. However, these changes have limits in centralized production techniques, and many industries are beginning to meet those limits. BMW's Mini, for instance, is now available in over 10,000 variants and has to make use of 3D printing in some cases to meet their customers' demands. Bentley has also begun to do so.

3D printing describes a group of technologies that have been in existence for over 30 years. With the recent expiration of key patents, innovation and hype have accelerated the industry, which has grown six fold in the last decade. Much of this growth is attributed to final part manufacturing, which has grown to 30% of service revenue in an industry entirely focused on prototype production as recently as 2002.

3D printing Enables Direct Manufacturing

Although 3D printing has existed for nearly three decades, the technology has only recently entered the public vernacular. Originally designed by Chuck Hull of 3D Systems for prototyping automotive parts, 3D printing has since expanded to functional prototyping, customization of aesthetic parts and short-run production.

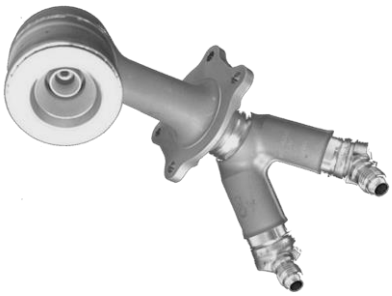


Figure 1: GE LEAP Fuel Injection Nozzle

General Electric will be 3D printing 25,000 fuel nozzles per year for the LEAP jet engine. The assembly combines 18 disparate parts into one cohesive piece that requires minimal post-processing and no assembly labor. The part is 25% lighter and 5x the durability of the original part – just one of the uses for GE's more than 300 3D printers.

Figure 2: 3D Printed Acetabular cup

Hearing aids, acetabular cups and dental braces are all now shipping thousands or millions of 3D printed units. In some cases, the core advantage to these products is their customization, in others, some it is the ability to reduce weight, wastage or part count of the item. Increasingly the core advantage of 3D printed objects is moving from freedom of the design to its ability to lower the minimum economic production quantity.

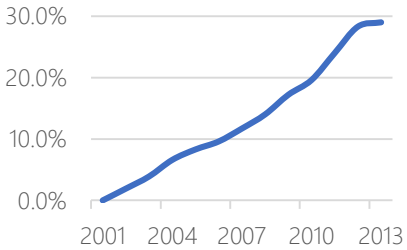


Figure 3: Rise of finished parts as percentage of all 3D prints (source: Wohlers)

Distributed Manufacturing is next on the Trajectory of 3D printing

Before 2002, the use of 3D printing for final good production was almost non-existent. Today, nearly one in three uses of a 3D printer are for finished goods. Industry experts estimate this could be as high as 80% by 2020, representing as much as 10% of total manufacturing by 2027.

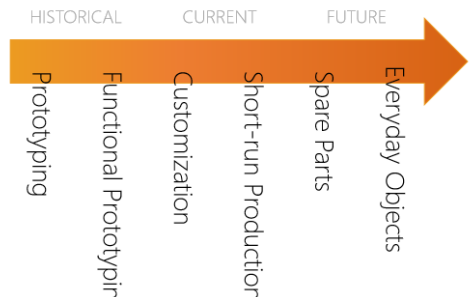


Figure 4: Evolution of 3D printing use cases

Future cost competitiveness is an unmistakable driver. In 2013, IBM looked at four exemplifying products to estimate the future impact of digital manufacturing technologies like 3D printers and CNCs. Already, strong advantages exist for 3D printing hearing

aids that are custom-fit for comfort and performance for each patient. While complex electronic devices like the iPhone will not be manufactured digitally anytime soon, simpler electronics and white goods will be impacted significantly.

This rapidly evolving trajectory points to the use of 3D printing for every day components, closer to the point of use. This is also reflected in the growing maturity of industry standards, which make remote manufacture feasible. The number and complexity of these has increased tenfold in the last 5 years.

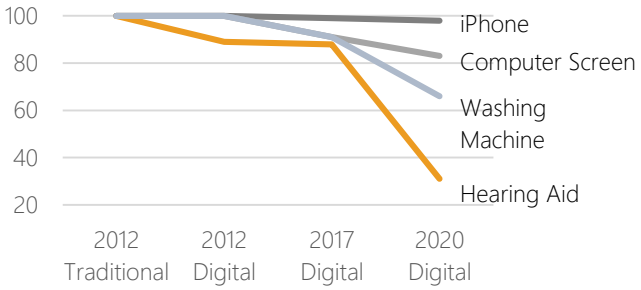


Figure 5: Digital prices indexed against traditional manufacturing (source: IBM)

Opportunities in Distributed Manufacturing

Supply chain disruption is an opportunity for growth. Here's how.

Re-imagine your supply chain

Retailers feel most threatened by the advance of localized manufacturing techniques, fearful that they may be disintermediated. Manufactures believe they may have the most to gain by distributing their products directly to the point of consumption and bypassing their intermediaries. Both may be wrong.

Instead, those to adapt and develop comprehensive strategies for new distribution paradigms are most likely to gain from them. Not only are they more likely to obtain brand value and loyalty by satisfying customer demand for faster delivery and customized service, but capturing mindshare as a distributor of digital designs for localized manufacture represents the best defense against disintermediation.

Comprehensive strategies are developed through engaging with the market. To do so, many companies make use of their core assets – the designs – in experiments that directly touch their customers and staff. Such engagement indicates that these companies have understood what the transition to distributed manufacturing means to them: they are becoming intellectual property publishers.

Initially, any engagement will have a limited mandate as companies try to understand the technology and its limits, and sensitize its stakeholders to the new technology. Specifically, successful experiments will likely deal with objects that have following features:

- End-of-line components: where inventory cost outstrips profit margin;
- Objects with high downtime cost: For failure in aviation, extraction, and other critical infrastructure, where non-performing time costs are the main driver;
- 3D printed form factor: objects that are small, complex and comprised of single materials are perfectly suited for 3D printing;
- Customization required: since complexity is free in 3D printing, objects that require customization are among the first to benefit.

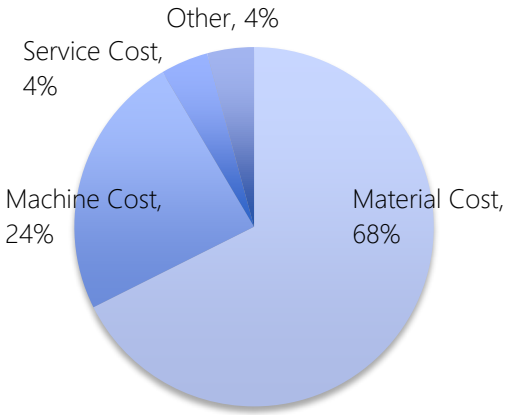
The expansion from these early limits is set by executive engagement, process improvements and business strategy. All these factors are inside the company's ability to influence, ensuring scalability once initial experiments have proved use cases successfully.

Addressing challenges

As the industry scales, engineers are committing increased resources to address process challenge in 3D printing. These include improving speed, reliability and replicability of 3D printing across the 7 different technologies used under that umbrella. Additionally, work engineering projects currently being conducted in the industry include:

1. Improving size limitations of current 3D print machines to allow for objects of all sizes to be built by 3D printers (by Voxeljet and others)
2. enabling multi-material prints in the same machine to create more life-like products (by Stratasys and others)
3. improving price competitiveness by ensuring cheap and consistent material availability (by MadeSolid and others)

For each of these initiatives and dozens others like them, current 3D printing failure points represent business opportunities to organizations. Successful companies engaging with the market often identify these failures as part of their own initiatives to embed 3D printing in their value chains, and spin out pragmatic solutions to these issues internally and externally. Nearly two years after publicly committing to build the LEAP fuel injection nozzle, GE has now made such a commitment: it recently announced a $50m, 300,000 sq. ft. 3D printing factory in Auburn, Arkansas to scale up production.



Example cost structure of a print conducted on a 3D Systems sPro 230. Source: Senvol

New supply chains – new businesses

The transformation of supply chains affords significant opportunity in the creation and distribution of tools that mimic and extend previously physical processes in the new digital supply chain. These tools could be as simple as an ERP integration tool to complex geometric search and automated modelling tools. Such opportunities are identified through physical or theoretical experimentation with the technology in a particular vertical. An example, the distributed manufacture of an aviation spare part, is listed below. The process of launching such a project would include following steps:

Example Step	Company engaging
Design Discovery (i.e. what is 3D printable?) *Creating and searching CAD databases. Auto-discovery of requirements*	SENVOL
Design Optimization (i.e. make it printable) *Use Finite Element Analysis, etc. to create optimal 3D model given constraints.*	WITHIN
Design Certification (i.e. can it fly?) *Enabling pre-print certification of design based on standard processes*	Lawrence Livermore National Laboratory
Object Purchase (i.e. buying the file) *Finding the file, either by end customer or intermediary*	
License Management (i.e. get it to the printer) *Secure transmission, object discovery, order entry, ERP integration, others*	AUTHENTISE
Local Production (i.e. making the object) *Individual or network digital production centres in all major cities, certified*	ups
Process Monitoring (i.e. is it printing right?) *In-build and post-build non-destructive testing of spare parts*	Sigma Labs, Inc.
Post-process Automation (i.e. finish the part) *Automated completion of design for full traceability*	Plethora

Startups and established organizations such as those listed alongside each step are already beginning to explore many of the opportunities that distributed manufacturing paradigm presents. Authentise is exploring issues as diverse as secure delivery and customization for its clients. At this stage, many opportunities are left unclaimed and organizations investing strategically are still able to take a leadership position, especially if they base their tools and services on needs identified during their own initiatives to engage with distributed manufacturing.

Partners

The process of adopting to such fundamental shifts in production is daunting, but there are partners to help. With its network, Authentise can provide you with a comprehensive pilot program that sensitizes customers and tests assumptions

Authentise Consulting

Authentise Consulting Inc. helps the Global 2000 build pilots to test their engagement with distributed manufacturing. Its role starts when innovation officers have identified potentially valuable interventions but wish to answer key questions regarding market and viability, and want to sensitize customers and executives before launching a company-wide initiative. Authentise Consulting builds on the licensing technology of its parent company, Authentise, as well as its deep partner network, to deliver a comprehensive customer facing solution with which key assumptions can be tested. Among its customers are leading retailers and manufactures. The company is based in Mountain View, California. For more information please visit www.authentise.com/services

Authentise

Authentise Inc. is the parent company of Authentise Consulting and offers a licensing platform for 3D printing. It permits its customers, among them the some of the leading design marketplaces in the industry, to manage and securely distribute design files for distributed manufacturing. Through its fully customizable API, design owners and intermediaries use its service to send design files directly into the end user's printer, without ever sharing the raw design file. In doing so, Authentise enables:

Figure 6: Authentise's 3D Print licensing platform allows pay-to-print design distribution.

- Revenue security: Design streaming enables Pay-to-Print design monetization, making sure that design owners and intermediaries get paid for each print of the object.
- Design integrity: The design stream means that the end design cannot be tampered with prior to print.
- Simple print: The Authentise API enables your customers to print directly from your website, ensuring simplicity in the print process vs. the current convoluted process: manual download and processing.
- User Marketing & Analytics: Since the print is happening directly from your website you are able to capture both eyeballs and analytics for the duration of the 5+ hour print.

For more information please see www.authentise.com