CHAPTER 3

The Impact of Additive Manufacturing on the Supply Chain

Consumer Packaged Goods

Research Support Service

April 2020

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Executive Summary

This report is the third in our four-part series exploring how additive manufacturing and 3D printing are reshaping industries.

Consumer Packaged Goods (CPG) is one of many major industries on which 3D-printing technologies will have a profound effect due to the rapid changeover and minimal complexity of many products in this vertical compared to others. Hence, AM is poised to caused earlier disruption in the CPG industries compared to the natural resources, aerospace and high-tech industries.

Among the CPG categories, products that are already composed of the typical thermoplastic polymer filaments used in 3D printing machines are poised to be early disruptors, such as **toys**, **cosmetics**, and **clothing accessories**.

AM is poised to caused earlier disruption in the CPG industries compared to the natural resources, aerospace and high-tech industries.

As new polymer chemistries become available for AM, metal 3D printing is embraced by CPG companies and larger 3D printing AM machines become available, AM will continue to evolve into **shoes, home and kitchen products, sporting goods and outdoor products**.

Categories such as **woven and non-woven textiles and hygiene products** may not be early adopters until 3D printing machines can compete with the knitting and non-woven manufacturing processes in terms of cost and efficiency.

Executive Summary

The business case for utilizing AM in the CPG industry, while not necessarily limited to CPG, is the ability to accelerate product design and prototyping, customize products to enhance the consumer experience, enable lean production process with less waste, produce parts with enhanced complexity/functionality that would be difficult to achieve with traditional manufacturing means. The sum of these parts enables **new business models and opportunities** to operational efficiencies that early adopters can leverage for a competitive advantage in their space.

Currently, manufactured goods are “pushed out” of distribution channels and stocked by distributors/suppliers for distribution to retailers and, eventually, consumers. Where AM can become a primary manufacturing method, products can be printed locally and distribution will be driven by **localized demand**, as opposed to mass production. For example, goods that are currently produced in Asia markets may eventually be produced locally, reducing transportation, storage, handling and distribution costs.

Additionally, AM will enable **mass customization and reduced material usage**. Mass customization both physically, ergonomically and aesthetically will shift consumer expectations and create a drive for customization as the new normal. Regarding reduced material usage, AM can complement a company’s sustainability efforts. In particular, novel forms of degradable/recyclable food packaging present a unique opportunity for the CPG industry.

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Executive Summary

AM is also enabling consumers to become manufacturers themselves. Creative consumers have been utilizing 3D printing machines to form companies from their own homes in order to address needs not currently met in the market. These **niche products** can reach the market without requiring an initial investment for mold tooling, while the marketing and distribution are handled through services such as Amazon.

In the long term, the supply chain could change even more fundamentally from printing and distribution from localized hubs or to goods being printed **directly within the end consumer's home**.

After eliminating the need for onsite manufacturing altogether, IP/Trademark protection, quality assurance/consistency from the AM machine manufacturers, and file sharing protection will become **key components** of the production process.

It is predicted that by 2025, 4.2 billion people will be in the consuming class. For the first time, the number of people with discretionary spending will exceed the number of people struggling with basic needs. As a result, there will be a surge in overall CPG market demand. To embrace this growth, while adapting to increasing consumer demands for personalization and sustainability, CPG manufacturers will need to prepare for long-term disruption, as increased affordability of 3D printers, new and improved manufacturing techniques, an increased range of applicable materials (plastics, metals and ceramics) and the ability to print parts near or within customer's homes are driving utilization.

A 2014 report from Markets and Markets estimates that the global CPG market size for applications in CPG will reach USD 2.8 billion, with an expected CAGR from 2014-2020 of 21.9%. The highest growth in material consumption for AM across verticals was from CPG, driven by the use of AM to quickly optimize product design.

in **2013**

The share of material consumption for AM in consumer products was **396.4 TONS**

in **2020**

The share of material consumption for AM in consumer products to reach **1830.5 TONS**

with an expected CAGR of 24.4% by 2020

References:

1. https://www.mckinsey.com/industries/consumer-packaged-goods/our-insights/tough-choices-for-consumer-goods-companies
2. https://www.marketsandmarkets.com/PressReleases/additive-manufacturing-material.asp

AM IN CONSUMER PACKAGED GOODS
DISRUPTING INDUSTRY

Top reasons why AM will disrupt the CPG industry

1. **Customized/personalized products:** 3D printing enables product customization/personalization with minimal increased costs, improving customer value and variety (such as the Invisalign dental braces).

2. **Decreased time to market:** Additive manufacturing can produce products directly at the point of use, enabling faster availability of parts, lower working capital and rapid prototyping of new design concepts.

3. **Reduced obsolescence of parts:** Companies will be able to remanufacture parts for cases in which the suppliers no longer exist physical molds of older parts, tooling and fixtures are unavailable (e.g., companies with large, long-lasting asset bases).

4. **Minimized supply chain:** On-site production, whether at hubs near residences or directly within a consumer's home, will greatly streamline CPG logistics.

AM IN CONSUMER PACKAGED GOODS
USE CASES

Consumer packaged goods encompasses a wide range of products, typically with short lifespans and intended to be used quickly, that are sold by retailers across various industries: baby care, food & beverage, health & beauty, jewelry, household & cleaning supplies, paper products, furniture, sporting goods, apparel and pet care.

The focus in this report for CPG is to provide examples of use cases to showcase the various ways in which AM is being leveraged to gain market share and their level of technological maturity. For example, 3D-printed toys, cosmetics, jewelry and packaging are already being sold to consumers. Other categories, such as furniture and apparel, will be soon to follow.

Regardless of the category, AM is being embraced by companies to reduce design and prototyping times during the product-planning phase.

The following examples highlight just a few use cases for various subcategories of products within the CPG space. It is an exciting time as manufacturers, designers and engineers are experimenting with AM to offer their customers a customized brand experience and better functionality.

USE CASES - COSMETICS

Mink has been developing a 3D makeup printer since 2013 and initial units are expected to be shipped in the fall of 2020. Created by Grace Choi, the printer converts images into 3D-layered makeup products, enabling consumers to re-create any shade of eyeshadow, lipstick and even nail polish imaginable from what they view in an image.

Images of the in-development Mink 3D makeup printer. Source: Mink.

References:
https://www.prnewswire.com/news-releases/mink-launches-3-d-makeup-printer-stream-your-makeup-on-demand-300869889.html:

USE CASES - COSMETICS

smashbox

In 2016, Smashbox utilized the power of AM to develop custom lipsticks for their customers in an interesting blend of marketing and tech innovation. Consumers would choose from 120 different lipstick shades of Smashbox's #BeLegendary collection. Once they picked their color, it was printed on a compact in any desired shape using a 3D printer.

#BeLegendary120 Lipsticks. Source: Smashbox.

References:
https://all3dp.com/smashbox-launches-3d-printed-lipsticks/
https://www.teenvogue.com/story/smashbox-custom-3d-printed-be-legendary-lipstick

AM IN CONSUMER PACKAGED GOODS
USE CASES - APPAREL

Adidas announced in 2017 that it partnered with Carbon, a Silicon Valley–based tech company, to create 3D-printed soles. Adidas used digital light synthesis (DLS) technology to generate high-performance, durable, polymeric products. The new product line is known as Futurecraft 4D and it was the first AM application to Adidas products. With this new technology, Adidas enables new athlete data-driven design and manufacturing.

The 3D-printed midsole for Adidas's new running shoe. The midsole is made via digital light synthesis. Source: 3DNatives.

References:
https://www.carbon3d.com/news/adidas-unveils-industrys-first-application-of-digital-light-synthesis-with-futurecraft-4d/
https://www.3dnatives.com/en/adidas-futurecraft-4d-220120184/

AM IN CONSUMER PACKAGED GOODS
USE CASES - APPAREL

New Balance released Zante Generate in 2016, in partnership with 3D Systems. Zante Generate is a running shoe with a full-length 3D-printed midsole, and only 44 pairs were released. Using the selective laser sintering (SLS) technique, the new running shoes' sole performed significantly better in terms of durability and elastomeric capability due to the unique programmable polymer used. In 2019, New Balance released the Tripecell sneaker with a 3D printing forefoot in collaboration with Formlabs.

New Balance's Zante Generate running shoes. Source: New Balance.

References:
https://newbalance.newsmarket.com/images-and-videos/running/new-balance-zante-generate---pair/a/80aa6112-0376-4170-910e-e06215888f87
https://www.3dprintingmedia.network/new-balance-triplecell-platform-3d-printed-footwear/

USE CASES - SPORTING GOODS

The bicycle helmets offered by Kupol are a great example of leveraging AM for not only prototyping but production as well, due to the complex structural requirements of the end-user application. In addition to accelerating the whole product development process, in this case, AM also enabled the creation of complex structures that could not be produced with another technique. With Kupol's bike helmet, the head remains cool due to an innovative plastic structure that is 3D printed.

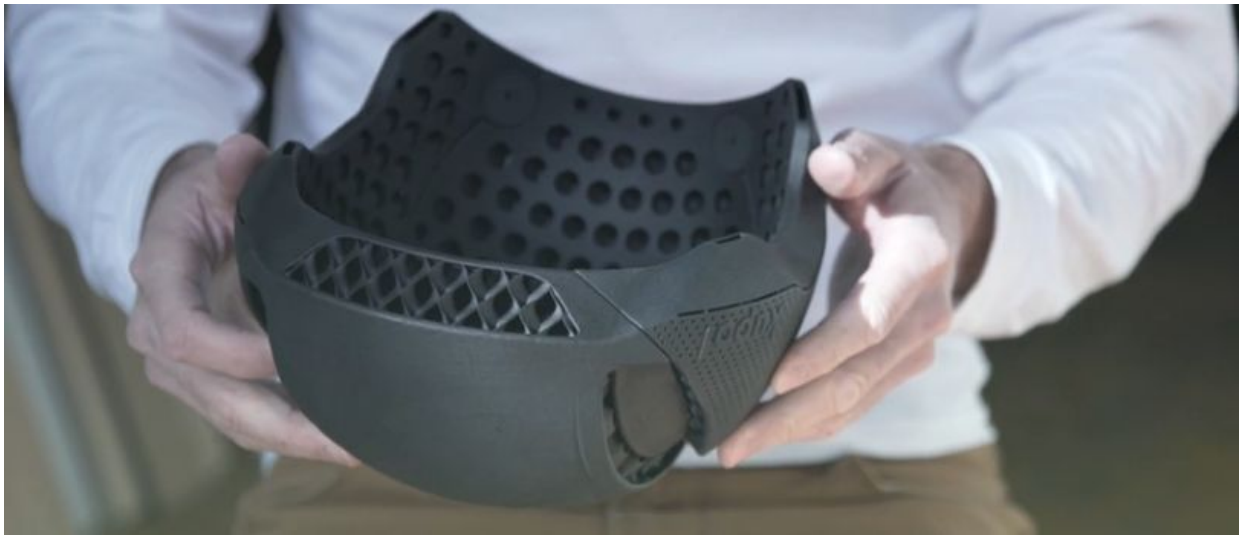


Image of the 3D-printed Kupol helmet. Source: Sculpteo.

References:
https://www.sculpteo.com/blog/2017/11/29/3d-printed-bike-helmet-discover-the-kupol-project/

USE CASES - SPORTING GOODS

AREVO

Silicon Valley startup Arevo has developed a proprietary robotic 3D printing process that uses PEEK filaments, reinforced with continuous carbon fiber. Their technology enables them to produce carbon-fiber bikes, which have been historically very expensive and labor intensive to manufacture, at a competitive cost. The AREVO DNA AM process reduces the design and final manufacture of the bike frame from 18 months to just a few days with a significant reduction in product development costs.

Example of 3D-printing bike using Arrevo's technology. Source: Emery Bikes.

References:
https://arevo.com/news_item/arevo-to-manufacture-worlds-first-3d-printed-carbon-fiber-unibody-bike-frames-for-new-line-of-ebikes-from-franco-bicycles/
https://amfg.ai/2019/03/12/10-exciting-ways-3d-printing-is-being-used-in-the-consumer-goods-industry/
https://emerybikes.com/

USE CASES - HOME GOODS

KALLISTA

Kallista, a division of Kohler, partnered with 3rd Dimension to using Direct Metal Printing (DMP) to design and manufacture the Grid Faucet in a matter of weeks. The Grid Faucet features right angles and integrated water channels that could not be easily manufactured using traditional manufacturing methods.

Example of the Grid Faucet. Source: Kallista.

References:
https://www.additivemanufacturing.media/blog/post/direct-metal-printing-rapidly-delivers-innovative-faucet-
https://www.kallista.com/bathroom/faucets/sink-faucets/grid-sink-faucet-cube-handles-p26100-cu-bl/

USE CASES - TOYS

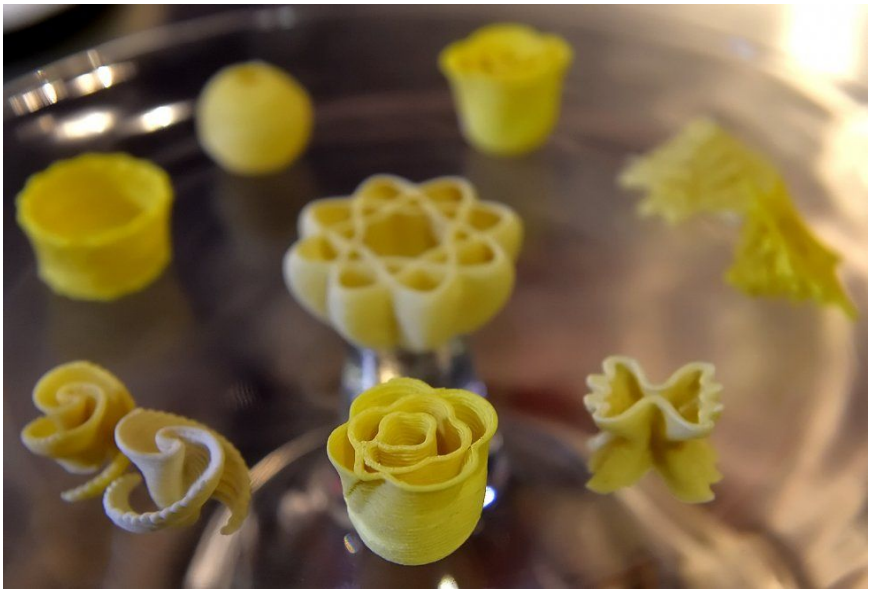
In 2014, Hasbro partnered with Shapeways to launch SuperFanArt, which is a website through which customers can design and create their own toys with a 3D printer. The pilot program utilized My Little Pony to test the market's reaction. On SuperFanArt's page, customers could create and share their designs and even sell their 3D-printed toys to others. Customers could also browse through artists' designs and place orders. While the program was a successful demonstration of a novel business models that may emerge from the collaboration between 3D printing communities and brands, the program ended in 2015.

SuperFanArt's 3D-printed ponies with customized designs. Source: Variety.

References:
https://variety.com/2014/biz/news/my-little-pony-hasbro-lets-consumers-design-their-own-toys-through-3d-printing-1201265593/
https://www.businesswire.com/news/home/20140721005348/en/Hasbro-Shapeways-Launch-SuperFanArt-New-Website-Empowers

USE CASES - FOOD & BEVERAGE

At the 2016 International Food Exhibition, the world leader in pasta sales, Barilla, showed a pasta 3D printer, which can produce four unique pasta shapes in two minutes. In collaboration with the Netherlands Organization for Applied Scientific Research, Barilla takes food development and the dining experience to a new level. Not only can this printer change the shape, but it also customizes doughs. In the future, it will also control the nutritional value, textures and colors of the pasta. In 2019, Barilla launched a pasta printing spinout named BlueRhapsody.



Customized pasta printed by Barilla's 3D printers. Source: 3D Printing Creative.

References:
https://www.3dprintingcreative.it/barilla-stampa3d/
https://thespoon.tech/barilla-backed-blurhapsody-to-launch-3d-pasta-printing-e-commerce-service-in-2019/

AM IN CONSUMER PACKAGED GOODS
USE CASES - PACKAGING

Another huge opportunity for the utilization of additive manufacturing in CPG is packaging development. While AM will most likely not compete from a cost standpoint against current packaging manufacturing processes, AM is being used to accelerate the packaging design and prototyping process. AM enables companies to rapidly assess new luxury and personalized packaging designs and their manufacturability while saving considerable waste before production. The waste minimization is enabled by the bottom-up approach of most AM techniques and the elimination of new tooling.

TOLY
Passionate About Packaging

Toly Group has embraced the advantages of AM for packaging design and has leveraged AM to create models and new designs for its clientele in the cosmetics space. They are able to quickly provide new packaging concepts with aesthetic enhancements, while at the same time providing more eco-friendly packaging by using thinner or hollow parts or lighter-weight materials.

Image of a product made using a 3D printer. Source: Packaging Europe.

References:
https://www.3dz.com.mt/toly-group/
https://packagingeurope.com/eco-design-for-high-end-packaging-using-multijet-3d-printing/

AM IN CONSUMER PACKAGED GOODS
USE CASES - NICHE PARTS

AM machines place the power of manufacturing at our fingertips by offering the ability to rapidly design, prototype and refine without tooling and at lower cost than conventional manufacturing technologies. Hence, AM is enabling customers to create their own unique solutions to everyday challenges and start their own businesses.

Pengraff UK, a small business located in the United Kingdom, uses 3D printers to provide custom mounting solutions for consumer electronics, such as routers and other hardware. Since starting in 2017, they have sold over 20,000 3D printed products to customers in the UK and continental Europe.

Image of a product made using a 3D printer. Source: Additive Manufacturing Media.

References:
https://www.additivemanufacturing.media/articles/how-3d-printing-enables-sustainability-in-a-high-turnover-consumer-market

USE CASES - NICHE PARTS

defox

Defox is an Oregon-based startup that manufactures the Periscope Case, a smartphone case that holds a mirror at a precise 45-degree angle so the camera sees a perpendicular view, like a periscope. AM enables niche products such as these to get to market without requiring an initial investment for mold tooling, while the marketing and distribution are handled through Amazon.

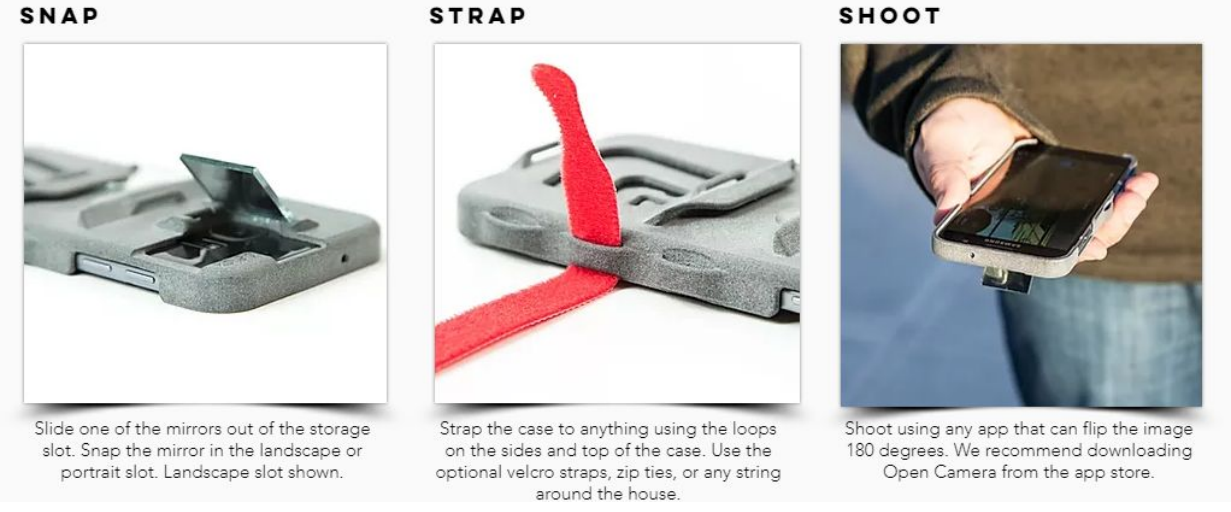


Image of a product made using a 3D printer. Source: Periscope Case.

References:

https://www.periscopecase.com/

AM IN CONSUMER PACKAGED GOODS
IMPACT ON SUPPLY CHAIN

AM will accelerate a shift from “push supply chains” to “pull supply chains.” Due to customization demand in the CPG market, long production runs for mass production will give way to limited production runs for customer-driven mass-customization products. With AM, manufacturing will become more agile and better able to react to customer demands. Thus, fewer products that are *works in progress*, *products in transportation* and *products in stock* will reduce the overall cost of product life cycle.

To be more specific, the impact of AM in supply chains would be seen in five areas: the supply chain structure, inventory management, transport time, component lead time and customer responsiveness.

SUPPLY CHAIN STRUCTURE →

Due to the capability of AM technology to fabricate more complex parts, the consolidation of function will play a major role in changing the supply chain. For example, in traditional manufacturing, different parts need to be manufactured and assembled, whereas when using AM, a more complex part without the need to be assembled can be produced. **Therefore, the need for multi-level production planning is removed, simplifying the supply chain structure.**

Inventory management

As a result of the simplified supply chain structure, inventory level will be reduced. For example, in the traditional production model, downstream stocks are needed, since a high inventory level will speed up the response time between different production levels. **Since AM technologies directly convert raw materials into products, the inventory level for middle chains are reduced.**

IMPACT ON SUPPLY CHAIN

Transport time

Because of the decentralized production of AM, production sites are closer to end customers. Thus, a reduced distribution time is realized.

Component leading time

In traditional manufacturing models, a large amount of components are produced at one time to reduce costs, therefore a long lead time is inevitable. In a multi-level production process, multiple lead times and component planning are costly. With AM, the lead time could be dramatically decreased.

Customer responsiveness

Due to the flexibility of AM manufacturing, a more agile response to a customer's special requirements can be realized easily.

AM IN CONSUMER PACKAGED GOODS | IMPACT ON SUPPLY CHAIN

AM will change the supply chain to “pull supply chains.” Below, is a comparison of a traditional supply chain vs an AM supply chain:

A Traditional Supply Chain	A 3D Printing Supply Chain:
Products are mass produced (e,g. in China)	Customized production
Manufactured goods are 'pushed out' and distributed through warehouse network to customers	'Pulled' by end customer demand
Long lead time	Locally printed and distributed
High transport costs	Short lead time
Large carbon footprint	Low transport costs
	Low carbon footprint

As opposed to mass production, 3D will enable mass customization and reducing material usage. Instead of manufactured goods being “pushed out” of distribution channels to consumers, goods will be localled printed and distribution driven by localized demand. For example, goods that are currently produced in China or other Asia markets may eventually be produced locally, reducing transportation, storage, handling and distribution costs.

References:
https://www.3ders.org/articles/20130706-infographic-the-impact-of-3d-printing-on-supply-chains.html

AM IN CONSUMER PACKAGED GOODS | ON-DEMAND 3D PRINTING HUBS

UPS has announced plans to launch an on-demand manufacturing networks that connect its global logistics network with 3D printers at UPS Stores and its 3D printing factory in Louisville, Kentucky. With the network, customers will visit the Fast Radius website to place their 3D printing orders. The orders will then be directed to the best 3D printing factory or UPS Store based on the speed, geography and product quality that customers require.

This novel network will enable UPS to apply AM to implement an on-demand product manufacturing model with the potential to serve customers of all sizes, such as manufacturers seeking to decrease inventory for slow-moving parts, manufacturers with limited production runs and manufacturers of custom goods.

Examples of parts that are expected to be produced by UPS's Printing Hubs. Source: Additive Manufacturing.

References:

1. https://www.ups.com/us/en/services/high-tech/3d-print.page
2. https://www.additivemanufacturing.media/news/-ups-to-launch-on-demand-3d-printing-network-in-collaboration-with-fast-radius

AM IN CONSUMER PACKAGED GOODS
FILE SHARING RISKS

Although there are many advantages AM can bring to supply chains, potential risks need to be considered in regards to protecting IP and brand reputation through product quality as file sharing between businesses and consumers will become ubiquitous.

3D Print Design Distribution Channels

		Ideal for	Examples
Digital Distribution	Download	Sharing designs with as many people as possible	MyMiniFactory, Thingiverse, pinshape
	Stream	People who want IP protection, but still want to allow makers to print at home	SECURED 3D™, pinshape
Physical Distribution	Print Service	People who don't own a 3D printer	3D HUBS, SHAPEWAYS
	Online Marketplace	Selling 3D printed objects with a lower startup cost and less time	Etsy, STORENVY
	Selling in Person	Selling products without shipping costs	
Digital or Physical	Websites	People who want full control over their designs and products	KIT BASH 3D™

File Sharing

It is recommended that companies ensure the secure streaming of 3D CAD files via an application programming interface (API), thereby embracing a "pay-per-print" business model. This business model removes the need for a CAD file to be sent to the consumer. Instead, the build instructions are sent directly to the printer, which, in turn, prints out the number of objects that have been purchased. This model has been employed by companies such as Authentise, Secure3D, ToyFabb and the Hasbro Shapeways initiative.

Businesses could also consider licensing CAD files more widely, thereby opening up doors to a range of outlets selling 3D CAD files. This will avoid locking the manufacturer into an agreement through a system such as a "one-stop-shop" for spare parts.

- Physical protection against the use of 3D-scanning technologies may be implemented in the form of anti-counterfeiting tags embedded in 3D-printed objects.
- Blockchain is one of the ways to securely exchange 3D-printing files and control the conditions under which they are used, enabling many different potential scenarios at every level within an extended enterprise.

- The CPG vertical has the highest chance of disrupting how businesses approach B2C and B2B manufacturing, since many parts have smaller-form factors that can be printed directly in one's home and with currently available printing methods.

- Hence, as businesses and consumers gain their own in-house manufacturing capabilities, protecting digital files, maintaining secure file sharing and preventing counterfeiting for trademark reputation maintenance will become increasingly important.

- Ways to sell 3D models: The most frequently used methods of sharing objects are uploading those objects to a printer-neutral platform such as Thingiverse, followed by emailing files to individual people. Users not only distribute their own digital creations using online repositories, but also obtain a significant amount of designs from those repositories. Most of the creators of digital object designs use CC licensing when sharing their design files.

AM IN THE SUPPLY CHAIN
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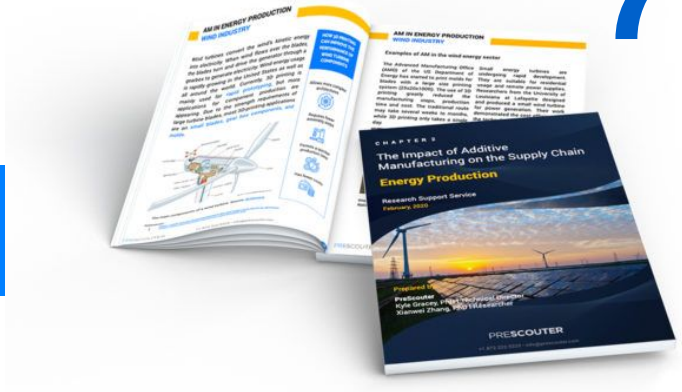

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High Tech --- *Upcoming*

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NEXT STEPS

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- MARKET RESEARCH & ANALYSIS
- TRENDS MAPPING
- ACQUIRE NON-PUBLIC INFORMATION
- PATENT COMMERCIALIZATION STRATEGY
- DATA ANALYSIS & RECOMMENDATIONS
- REVIEW BEST PRACTICES
- SUPPLIER OUTREACH & ANALYSIS
- CONSULT WITH INDUSTRY SUBJECT MATTER EXPERTS
- INTERVIEWING COMPANIES & EXPERTS

WE CAN ALSO DO THE FOLLOWING

- ✔ **CONFERENCE SUPPORT:** Attend conferences of interest on your behalf.
- ✔ **WRITING ARTICLES:** Write technical or more public facing articles on your behalf.
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