OFFICE OF INSPECTOR GENERAL
UNITED STATES POSTAL SERVICE

An Update on 3D Printing and the Postal Service

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OFFICE OF INSPECTOR GENERAL
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Executive Summary

3D printing is changing the world in ways that demand the attention of postal operators and anyone else who works in or adjacent to the logistics industry. In July 2014, the U.S. Postal Service Office of Inspector General issued a white paper detailing how widespread adoption of 3D printing could lead to a major increase in commercial package shipments for the U.S. Postal Service. However, recent research has shown that 3D printing's impact on the Postal Service goes well beyond just more packages shipped, as it promises to reshape today's supply chains and transform entire industries.

It appears that mainstream in-home 3D printing could still be a decade away. However, recent research also suggests that business adoption of 3D printing is having far greater impact on the global economy than previously imagined. Improvements in evolving 3D printing technology have accelerated its adoption in critical industries, across both new sectors and those that have been using 3D printing for years to revolutionize their processes. In addition, many retailers have entered the 3D printing market, which speaks to increasing demand. Consumers can now buy finished 3D printed goods from multiple providers and have them delivered without needing to purchase their own printer.

Experts say that the largest disruptions from 3D printing will fall on the logistics industry, which is very important to the Postal Service. In fact, 3D printing could disrupt more than a third of global air cargo or ocean container shipments, as well as a quarter of the freight trucking business. This would fuel a shift in shipping demand from long-distance transportation to last-mile delivery, with products printed locally instead of requiring assembly from parts coming from all corners of the world. These changes could catalyze the trend toward reshoring American manufacturing jobs that went overseas decades ago. In addition, warehouses will convert to digital inventories with on-demand printing, resulting in much less

Highlights

3D printing is changing the way goods are designed, produced, and delivered to customers.

Businesses are already using 3D printing to dramatically improve their products and processes, which has revolutionized entire industries.

A survey of manufacturers found that 3D printing's greatest disruption might be on global supply chains. There will be a heightened need for last-mile delivery, which is the Postal Service's core competency.

Shipping and logistics companies are already responding to 3D printing's significant impacts.

Foreign posts are partnering with 3D printing companies and offering services ranging from sales of 3D printed items to fully customized packaging.

need for thousands of spare parts that might sit on shelves for years. On top of that, small retail spaces will convert to showrooms for products that can be fully customized for each consumer.

Simply put, 3D printing will fundamentally change where and when products will be produced, stored, and ultimately delivered. Supply chains will collapse in distance and time as manufacturing is performed as quickly and as close to the point of consumption as possible. More consumers may come to expect same-day delivery, possibly even early morning and late evening delivery. There will be heightened activity in the last mile from localized production, so speed on that final track will be essential. In such an environment, the location and size of delivery base stations will also be critical.

Other organizations involved in logistics and delivery are taking note of 3D printing's possibilities and the vast changes it will bring about. For example, UPS recently partnered with the company CloudDDM to open a 3D printing mini-factory at its Worldport facility in Louisville, KY. The facility has 100 industrial printers running day and night to produce high-quality parts for corporate customers. UPS also offers 3D printing services inside many of its retail locations, geared toward supporting local businesses. In addition, a growing number of foreign posts are exploring the potential of 3D printing and related technologies. France's La Poste, for example, offers a range of services, including 3D printers inside post offices, 3D printed jewelry based on children's artwork, and fully customized packaging cut to the exact shape of delicate objects to offer protection during shipping. Additionally, the U.S. government is diving into 3D printing across a wide range of agencies, including NASA, the Department of Defense, and the National Institutes of Health.

Because 3D printing technology is fundamentally changing the logistics industry, now is the time for the Postal Service to associate itself with 3D printing in the minds of the public. The Postal Service should observe, learn, and examine the potential of 3D printing to the extent allowable under its existing authority. The examples of La Poste, UPS, and others show that there may be demand for printing services inside post offices. The Postal Service also could partner with 3D printing companies, provide 3D printing materials and support services for local small businesses, or serve as a community maker space. In addition, it could establish a reverse logistics service to handle recycling and processing of 3D printed goods, so that materials can be reused for future printing.

Waiting for a full-blown consumer 3D printing revolution could mean missing the multitude of ways that businesses are already embracing the technology and changing the world. Thanks to 3D printing, the supply chains of the future will little resemble the world we know today. Organizations might be ill equipped to work with tomorrow's supply chains without fully understanding the implications of 3D printing right now.

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It took only 500 days for 3D printing to fundamentally transform the entire U.S. hearing aid industry.

Introduction

In July 2014, the U.S. Postal Service Office of Inspector General (OIG) issued a paper showing how a 3D printing revolution could lead to a dramatic increase in commercial package shipments handled by the Postal Service.[1] The paper described two scenarios for the future of 3D printing, a technology that converts three-dimensional digital images into solid objects, usually one razor-thin layer at a time. In one scenario, consumers buy finished 3D printed products from retailers and have many of these products delivered to their homes. In the other, less likely scenario, people 3D print many objects at home and require regular delivery of printing materials.[2] Because 3D printing under either scenario could be done at a local level, it promises to reshape existing supply chains and bolster the importance of the Postal Service's nationwide network and last-mile delivery capabilities.

Several recent developments further suggest that 3D printing has tremendous importance for the Postal Service and any organization with a presence along critical supply chains. For example, the 3D printing market continues to show strong growth, particularly in industrial sectors. An increasing number of companies now sell finished 3D printed products to businesses, consumers, non-profits, and other organizations. In addition, 3D printing's potential impact on the logistics industry is beginning to take shape, as some major companies involved in logistics and delivery are exploring innovative uses of the technology. Moreover, NASA, the U.S. military, and a number of other federal agencies are using 3D printing in various ways, improving the efficiency of scientific research and the flexibility of their operations.[3] Perhaps most importantly, international postal operators are already providing a range of 3D printing services. This paper highlights some of these developments and offers suggestions for how the Postal Service might react to the emerging 3D printing marketplace.

At a basic level, 3D printing takes digital representations of objects and creates them in physical form by building up multiple layers of plastics, metals, powders, liquid resins, and other materials. People often refer to 3D printing as additive manufacturing to contrast it with traditional "subtractive" manufacturing techniques, which involve cutting, milling, or otherwise removing material to create an object.[4] A major part of 3D printing's appeal is that it allows for an unprecedented degree of rapid prototyping and mass customization.

While media coverage of 3D printing has often focused on cheap plastic 3D printed goods — such as smartphone cases, figurines with people's faces scanned onto them, and other customized knickknacks — some of the most important advances in 3D printing are taking place in business applications. Manufacturers have used it for decades to do rapid prototyping of new products. More recently, 3D printing has been employed for uses as varied as revolutionary prosthetic limbs, aircraft jet engine parts that weigh significantly less and have fewer components than previous parts, and even simple houses.[5] In fact, 3D printing has already fundamentally changed some industries. For example, a recent *Harvard Business Review* article reported that it took only 500 days for all hearing aid manufacturers in the United States to make the switch to 3D printing-based fabrication.[6]

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1 U.S. Postal Service Office of Inspector General (OIG), *If It Prints, It Ships: 3D Printing and the Postal Service*, July 7, 2014, Report No. RARC-WP-14-011, https://www.uspsoig.gov/sites/default/files/document-library-files/2014/rarc-wp-14-011_if_it_prints_it_ships_3d_printing_and_the_postal_service.pdf.

2 These two scenarios are not mutually exclusive.

3 Appendix A describes some of the innovative and unique ways that NASA, the U.S. military, and other federal agencies are using 3D printing.

4 Gartner, *Market Guide for 3D Printing*, December 3, 2014, p. 2 and Alan Earls and Vinod Baya, "The Road Ahead for 3-D Printers," PwC, *Technology Forecast: The Future of 3-D Printing*, Issue 2, 2014, pp. 3-4. Please note that some people use the terms "3D printing" and "additive manufacturing" synonymously, while others say that 3D printing is a subset of a larger body of additive manufacturing techniques.

5 Enabling the Future, http://enablingthefuture.org/about/; GE Reports, "Fit to Print: New Plant Will Assemble World's First Passenger Jet Engine With 3D Printed Fuel Nozzles, Next-Gen Materials," June 23, 2014, http://www.gereports.com/post/80701924024/fit-to-print; and Rory Stott, "Chinese Company Showcases Ten 3D-Printed Houses," *Arch Daily*, September 2, 2014, http://www.archdaily.com/543518/chinese-company-showcases-ten-3d-printed-houses/.

6 Richard D'Aveni, "The 3-D Printing Revolution," *Harvard Business Review*, May 2015, https://hbr.org/2015/05/the-3-d-printing-revolution.

Due to its ubiquitous physical network and unmatched last-mile delivery capabilities, the Postal Service is a perfect fit for shipping 3D printed goods.

Taken as a whole, 3D printing is transforming manufacturing and reconfiguring supply chains not only within the United States, but around the world. It is changing the way consumers get the products they need and shifting power to individuals with unique preferences. Postal operators and nearly every organization that works in shipping, delivery, or other aspects of logistics should keep a very close eye on it.

OIG Research on 3D Printing and the Postal Service

The OIG's 2014 white paper, *If It Prints, It Ships: 3D Printing and the Postal Service,* explained how 3D printing works and examined its potential impact on the Postal Service. Namely, the technology could lead to increased volume in the kind of small, lightweight package shipments that the Postal Service excels at delivering. Its ubiquitous physical network and excellent last-mile delivery service position the Postal Service to benefit more from 3D printing than other delivery companies will.[7]

The Postal Service has an unmatched last-mile delivery network — no other organization covers as much territory as frequently and regularly as the Postal Service. It is often not cost effective for private delivery firms to make separate stops to deliver small, relatively inexpensive packages, particularly in rural areas. However, the Postal Service visits these locations nearly every day. Accordingly, other delivery firms often use the Postal Service for final delivery of many packages: the Postal Service delivers nearly two-thirds of lightweight, commercial packages to their final destination.[8] This natural advantage in delivering lightweight packages is critical to benefiting from the growth of 3D printing given that the majority of 3D printed consumer goods are relatively lightweight.[9] In addition, the Postal Service has begun introducing new Small Parcel Sorting System (SPSS) machines at plants across the country, which are intended to help it to quickly process many small packages.

Discussion Forum on 3D Printing and Postal Organizations

In August 2014, the OIG held a discussion forum to further explore how 3D printing could affect postal organizations. The forum included presentations by international experts on 3D printing, logistics, and other key areas.[10] The discussion covered a range of topics, including the future market for 3D printing, consumer preferences related to 3D printing, the effects of 3D printing on supply chains and logistics, establishing community maker spaces through 3D printing, and other issues.

Participants at the forum discussed some of the major implications of 3D printing for postal organizations and logistics operators. Our subsequent research into recent developments in 3D printing supports the following findings:

- For the immediate future, most consumers will likely access 3D printing by purchasing finished goods or pieces through businesses or service bureaus that specialize in 3D printing. In-home 3D printing on a wide scale still requires technological advancement and more consumer awareness of 3D printing's capabilities. In addition, the software for developing or modifying 3D design files is still too complex for many consumers.

- There has been a rise in the number of service bureaus that produce professional-quality parts and finished products for businesses or consumers that need a way to access 3D printing, but typically do not have a 3D printer of their own.

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7 OIG, *If It Prints, It Ships: 3D Printing and the Postal Service*.
8 OIG, *Package Services: Get Ready, Set, Grow!*, July 21, 2014, Report No. RARC-WP-14-012, https://www.uspsoig.gov/sites/default/files/document-library-files/2014/rarc-wp-14-012.pdf.
9 For more information about the OIG's 2014 white paper on 3D printing, please see Appendix B.
10 The presenters included Christopher Barnatt, Futurist at ExplainingTheFuture.com and author of books on 3D printing; Jordan Brehove, Vice President of Solutions at MakerBot; Ken Lyon, Managing Director of the advisory firm Virtual Partners; and Justine Trubey, Vice President of Supply Chain and Manufacturing at Shapeways.

An August 2014 OIG discussion forum highlighted the ways that 3D printing could change supply chains and affect postal operators.

Sales of 3D printed goods and services could exceed $20 billion by 2020.

- Businesses that offer 3D printing sometimes face challenges with getting products in consumers' hands quickly for multiple reasons. When print jobs fail due to problems with the design or materials, it can add a day or more to the interim between when a customer places an order and when the product is delivered. In addition, it is often difficult or impossible to anticipate demand when so many 3D printed goods are customized for individual consumers. When modern consumers expect very fast shipping, even short delays can have a negative impact on their experiences ordering 3D printed goods.

- 3D printing promises to reshape traditional supply chains. 3D printing will likely bring production closer to consumption, which could lead to dramatic increases in local shipping. This could also lead to less need for redundant physical inventories in large warehouses. As items such as spare parts can be printed on demand, the nature of inventory will transform from physical to digital.[11]

The Changing 3D Printing Marketplace

The 3D printing industry is rapidly changing. While manufacturers have been using 3D printing for rapid prototyping for decades, it has recently caught a great deal of attention as a means of producing innovative goods. Widespread consumer adoption might still be years or even a decade away, but there are clear signs of strong current growth in businesses' use of 3D printing and of its impact on delivery and logistics markets.

3D Printing Technology Is Improving

Although many people talk about 3D printing as one technology, the field actually encompasses several. The most familiar — and the one most often found in consumer 3D printers — is material extrusion, which uses a heated nozzle to dispense materials like plastics to slowly build an object in fine layers. Other 3D printing technologies use different techniques, such as fusing powdered substances with a liquid bonding agent or heat, laminating sheets of materials together, or using lasers to selectively harden liquid resins.[12]

The company Carbon3D claims that its new 3D printing technology called Continuous Liquid Interface Production (CLIP) can print objects up to 100 times more quickly than previous technologies. CLIP uses ultraviolet light to harden a pool of liquid resin, with the solidified object rising up throughout the process.[13] It remains to be seen how widely this technology will be used, or if other new technologies make 3D printing even faster. However, some experts speculate that mass adoption of 3D printing could take off if new technologies make the process significantly faster and capable of producing stronger objects.[14] For industrial uses of 3D printing, variations in printers, quality or source of printing materials, and manufacturing practices can affect the consistency and quality of the functional parts being produced. Such challenges will need to be addressed before 3D printing reaches its full potential.[15]

The 3D Printing Market Is Expanding Quickly

Everyone agrees that the 3D printing market is growing. However, there are varying estimates of the market's current size as well as how large it will grow in coming years. Some estimates are based on sales of 3D printers alone, whereas others take into account sales of 3D printing materials and services as well. For example, Gartner estimates that worldwide shipments of 3D printers will increase at a compound annual growth rate (CAGR) of nearly 107 percent through 2018, at which time the annual

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11 There may still be a need to maintain physical inventories of printing materials and other supplies.
12 Gartner, *Market Guide for 3D Printing*, pp. 5-6.
13 For more information, please see the Carbon3D website at http://carbon3d.com/.
14 Richard D'Aveni, "The Time to Think About the 3D-Printed Future Is Now," *Harvard Business Review*, May 6, 2015, https://hbr.org/2015/05/the-time-to-think-about-the-3d-printed-future-is-now&cm_sp=Article-_-Links-_-Top%20of%20Page%20Recirculation.
15 U.S. Government Accountability Office, *3D Printing: Opportunities, Challenges, and Policy Implications of Additive Manufacturing*, June 24, 2015, Report No. GAO-15-505SP, http://www.gao.gov/assets/680/670960.pdf, p. 24.

It could be another 5 to 10 years before in-home 3D printers truly become mainstream.

money spent on 3D printers will reach more than $13.4 billion. Those estimates do not include 3D printing supplies or services.[16] Canalys includes printers, materials, and services in its estimates and says that 3D printing will reach $20.2 billion by 2019.[17] Similarly, longtime industry observer Wohlers Associates recently boosted its estimate for revenue from all 3D printing products and services, stating that it will exceed $21 billion by 2020.[18] Finally, an expansive forecast by McKinsey Global Institute found that the total economic impact of 3D printing could be as large as $550 billion per year by 2025.[19]

One sign of this growth is the recent surge in the number of major retailers that have started selling 3D printers, products, or printing services, including Staples, Home Depot, Walmart, Best Buy, Amazon, and Target. According to Gartner, merchants are entering this space because 3D printing addresses two critical trends in retail: "consumers' expectations of stock availability and their desire for personalized and customized products, services and shopping experiences."[20]

Despite strong growth in the 3D printing market overall, experts estimate that mainstream consumer adoption of 3D printing is still 5 to 10 years away.[21] One possible reason: many of the things that today's affordable consumer 3D printers can make, such as toys or small trinkets, are the kinds of things consumers can already purchase cheaply and easily at stores or online.[22] Moreover, the printers themselves may still be too expensive for most people, especially when compared to the costs of traditional "2D" ink printers.[23] Consumer 3D printers can be complex, slow, and unwieldy to use. Analysts expect demand to increase as consumer-grade 3D printers become faster, cheaper, more capable of printing high-quality objects, and easier to use — including more user-friendly and accessible design software.

Even though mainstream consumer adoption of 3D printing may still be years away, many businesses and industries have already adopted 3D printing to revolutionize their products and processes. It has become a vital tool for advanced manufacturing, as important goods such as industrial parts can be produced with geometries that have not been possible with traditional methods. Additionally, 3D printing is now cost-competitive with traditional manufacturing for small production runs and production of single, customized units.[24] Such factors are having a dramatic effect on industries adjacent to manufacturers, and, as the following section discusses, this is especially the case for the logistics industry.

3D Printing Will Disrupt the Logistics Industry

The logistics industry is likely to experience some of the biggest changes resulting from 3D printing. For example, 3D printing may cause some manufacturing to move back to the United States. In addition, warehouses will shift from physical to digital, as the designs of spare parts are stored in vast libraries for future on-demand printing. Moreover, some retailers may convert to "shop windows" for manufacturers with custom printing as each item is ordered, keeping only a model in stock.[25]

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16 Gartner, *Forecast: 3D Printers, Worldwide*, 2014, October 20, 2014, pp. 1, 34.
17 Canalys, "Global 3D printing market to reach $20.2 billion in 2019," news release, April 14, 2015, http://www.canalys.com/newsroom/global-3d-printing-market-reach-202-billion-2019.
18 This is double what Wohlers Associates forecast in its 2013 report, which stated that the sales of 3D printed products and services would reach $10.8 billion by 2021. Wohlers Associates, "3D Printing and Additive Manufacturing Industry Expected to Quadruple in Size in Four Years," news release, August 19, 2014, http://www.wohlersassociates.com/press65.html and "Wohlers Report 2013," http://wohlersassociates.com/blog/2013/05/wohlers-report-2013/.
19 McKinsey Global Institute, *Disruptive Technologies: Advances That Will Transform Life, Business, and the Global Economy*, May 2013, http://www.mckinsey.com/insights/business_technology/disruptive_technologies, pp. 105, 110.
20 Gartner, *Hype Cycle for 3D Printing, 2015*, July 27, 2015, p. 20.
21 Gartner, "Gartner Says Consumer 3D Printing Is More Than Five Years Away," news release, August 19, 2014, http://www.gartner.com/newsroom/id/2825417.
22 Gartner, *Market Guide for 3D Printing*, pp. 3-4.
23 Gartner, *Hype Cycle for 3D Printing, 2015*, pp. 28-29.
24 Rick Smith, "3D Printing Is About To Change The World Forever," *Forbes*, June 15, 2015, http://www.forbes.com/sites/ricksmith/2015/06/15/3d-printing-is-about-to-change-the-world-forever/print/.
25 OIG, *If It Prints, It Ships: 3D Printing and the Postal Service,* p. 16 and John Manners-Bell and Ken Lyon, "The Implications of 3D Printing for the Global Logistics Industry," *Transport Intelligence*, August 2012, http://www.transportintelligence.com/forms/get_whitepaper.php?wpID=76, p. 3.

Some goods that used to require assembly from dozens or even hundreds of different parts can now be 3D printed in one or only a few parts.

3D printing could disrupt 41 percent of air cargo shipments, 37 percent of ocean container shipments, and 25 percent of the trucking freight business.

Moving Production Closer to Consumption

Some of the biggest changes promised by 3D printing center around where goods will be produced and stored, which will in turn influence how goods will be delivered to consumers. In fact, in a recent survey, 30 percent of manufacturers said that 3D printing's greatest disruption would land on supply chains.[26] According to DHL, aftermarket supply chains like warehousing and spare parts distribution will be particularly affected by 3D printing.[27] As 3D printing allows manufacturers to move production closer to the point of consumption, it can dramatically decrease the costs and environmental impact of maintaining global supply chains.[28] In addition, it could make supply chains more efficient by delaying production until the last possible point in the supply chain for a given product because 3D printing often responds to consumer demand for highly customized goods.[29]

Some goods that used to require assembly from dozens or even hundreds of different parts can now be 3D printed in one or only a few parts. If an increasing number of products can be 3D printed locally instead of requiring parts, components, or materials from around the world, this will shake up major parts of the transportation and logistics industry. In fact, some estimates have found that localized 3D printing could affect up to 41 percent of global air cargo shipments and 37 percent of ocean container shipments, as well as 25 percent of the trucking freight business that would have moved the goods coming in from air cargo or ocean containers. These major shifts could bolster the present reshoring trend, in which some manufacturing is moving back to the United States (and other home markets) due to rising manufacturing costs and other factors at international production sites.[30] 3D printing can address these problems by reducing manufacturing costs, increasing the flexibility of production, and producing higher quality products.[31]

All of these changes could have major implications for how goods make their way to consumers. As more goods and parts are produced locally, things that used to be shipped long distance might now only need last-mile delivery.[32] This is a critical opportunity for the Postal Service, as last-mile delivery is one of its core strengths. 3D printing may actually help retailers, providers of customized medical equipment like hearing aids, and other organizations meet the needs of consumers who increasingly expect fast delivery service, such as next-day or even same-day delivery.[33] Businesses will find efficiency gains through 3D printing because it not only makes production cheaper, it also saves them time and money by reducing the traveling distance needed to get products in the hands of customers.[34]

New Opportunities for Companies Involved in Logistics

3D printing offers logistics companies significant new opportunities to expand their services. For example, they could provide materials and support services to 3D printing companies, establish reverse logistics services to handle recycling and processing of 3D printed goods made of reusable materials, host data for 3D designs, or offer 3D printing services in warehouses or near major transportation hubs.[35] In addition, logistics companies already often provide replacement parts services for their clients — this could be done more efficiently by 3D printing from a digital inventory of spare parts and components, with minimal need for expensive

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26 PwC, "3D Printing and the New Shape of Industrial Manufacturing," June 2014, http://www.pwc.com/us/en/industrial-products/assets/3d-printing-next_manufacturing-pwc.pdf, p. 10.
27 DHL, *2014 Trend Radar*, http://www.dhl.com/content/dam/downloads/g0/about_us/logistics_insights/DHL_Logistics-TrendRadar_2014.pdf, p. 33.
28 Hans-Georg Kaltenbrunner, "How 3D Printing Is Set To Shake Up Manufacturing Supply Chains," *The Guardian*, November 25, 2014, http://www.theguardian.com/sustainable-business/2014/nov/25/how-3d-printing-is-set-to-shake-up-manufacturing-supply-chains.
29 Gartner, *Hype Cycle for 3D Printing, 2015*, p. 23.
30 PwC Strategy&, "2015 Commercial Transportation Trends," http://www.strategyand.pwc.com/perspectives/2015-commercial-transportation-trends.
31 Some logistics companies may find opportunities to transport 3D printing materials and supplies.
32 Darren Travers, "The Impact of 3D Printing on the Manufacturing and Logistics Sector," *Eureka Magazine*, January 21, 2015, http://www.eurekamagazine.co.uk/design-engineering-features/technology/the-impact-of-3d-printing-on-the-manufacturing-and-logistics-sector/72549/.
33 Hans-Georg Kaltenbrunner, "How 3D Printing Is Set To Shake Up Manufacturing Supply Chains."
34 Richard D'Aveni, "The 3-D Printing Revolution."
35 DHL, *2014 Trend Radar* and Hans-Georg Kaltenbrunner, "How 3D Printing Is Set To Shake Up Manufacturing Supply Chains."

storage space for pieces that clients or consumers may not request for years.[36] Third party logistics providers (3PLs) may need to adapt to 3D printing because it could reduce manufacturers' need for the global reach and distribution capability that 3PLs provide.[37]

UPS and Amazon Move into 3D Printing

Some major companies are already exploring ways to integrate 3D printing into their services and supply chains. For example, UPS has made significant investment in 3D printing, offering 3D printing services at about 100 of its UPS Store retail locations in the United States.[38] UPS gears this service primarily to small businesses that require a way to use 3D printing to meet their own customers' needs. The services offered include printing prototypes, creating complex parts to support small-scale manufacturing, designing custom accessories, and even printing architectural models.[39]

Additionally, UPS recently teamed with the company CloudDDM to start a 3D printing mini-factory inside its Worldport facility in Louisville, KY.[40] The factory has 100 printers running day and night.[41] These are industrial grade printers that use quality thermoplastics to create prototypes, parts for products, and other specialized items for business customers from the aerospace, automotive, medical, and other industries. Figure 1 below shows a row of CloudDDM industrial 3D printers.

Amazon may soon experiment with delivery trucks that 3D print goods while in transit.

Figure 1: CloudDDM's Industrial 3D Printers

Source: CloudDDM.com.

CloudDDM claims that running this many printers in a single location allows it to reduce production costs by up to 50 percent compared to traditional manufacturing. Moreover, by locating the factory at that UPS facility, CloudDDM says it can gain as much as a 6-hour advantage over its competitors, allowing it to enter more packages into UPS's network before its cutoff time each day. UPS handles all packaging and logistics for CloudDDM's products.[42] Through this arrangement, CloudDDM claims it is the first company able to offer same-day shipping for "dimensionally accurate 3D printed parts in real engineering plastics," which it says will be critical as "more and more companies move to rapid design iteration, virtual inventory, and fast-turn spare parts replacement."[43]

In the future, Amazon may also alter traditional supply chains using 3D printing. It recently filed patent applications for delivery trucks that 3D print goods while in transit to

36 Darren Travers, "The Impact of 3D Printing on the Manufacturing and Logistics Sector."
37 Hans-Georg Kaltenbrunner, "How 3D Printing Is Set To Shake Up Manufacturing Supply Chains." Generally speaking, 3PLs are companies that provide logistics services for other businesses that wish to outsource those functions. For more information, please see http://www.logisticslist.com/3pl-definition.html.
38 The UPS Store is a wholly owned subsidiary of UPS. For more information, please see http://www.theupsstore.com/about/pages/index.aspx.
39 The UPS Store, "3D Printing Services," http://www.theupsstore.com/small-business-solutions/Pages/3D-printing.aspx and Rachael King, "UPS Helps Entrepreneurs Make 3-D Printed Prototypes, *The Wall Street Journal*, http://blogs.wsj.com/cio/2015/03/30/ups-helps-entrepreneurs-make-3-d-printed-prototypes/.
40 UPS has a minority stake in CloudDDM. For more information, please see http://www.prweb.com/releases/2015/07/prweb12820508.htm.
41 According to CloudDDM, the factory requires only one employee on staff at any one time to do things like reload printing materials into the machines. The company ultimately plans to put as many as 1,000 3D printers in the factory in Louisville. For more information, please see Parija Kavilanz, "Louisville Factory: 100 Printers, 3 Employees," *CNN Money*, May 4, 2015, http://money.cnn.com/2015/05/04/smallbusiness/cloudddm-3d-printing-factory-ups/.
42 David Greenfield, "Industrial Scale 3D Printing: A New Approach," *Automation World*, May 12, 2015, http://www.automationworld.com/industrial-scale-3d-printing-new-approach and Parija Kavilanz, "Louisville Factory: 100 Printers, 3 Employees."
43 CloudDDM, "Industrial Scale 3D Printing Factory at UPS Announces another First, Same-Day Shipping," news release, June 29, 2015, http://ww1.prweb.com/prfiles/2015/06/29/12820508/CloudDDM%20-%20Same%20Day%20Shipping-Final.pdf.

customers. All items would be printed on demand, eliminating the need to maintain physical inventory.[44] The system is not in place yet, so it remains to be seen whether it is feasible. If it does work out, in-transit 3D printing could be a major new development in the world of package delivery.

Foreign Posts Are Exploring the Use of 3D Printing

Several foreign postal organizations already see the value in 3D printing. By embracing these new technologies, posts are meeting the emerging needs of consumers and businesses, enhancing the value of their brands, and positioning themselves for the future in which 3D printing will be more prevalent. For the 3D printing companies that partner with posts, the benefit comes in the form of more direct connections to millions of customers. Figure 2 below summarizes some of these posts' offerings.

France

In our July 2014 white paper, we mentioned how France's La Poste first began offering 3D printing services by forming a partnership with the company Sculpteo in late 2013. Through this partnership, La Poste placed 3D printers in three post offices in and near Paris and offered an online marketplace where consumers can order 3D printed products. Customers can submit their own designs or pick and customize from a catalog with about 40,000 existing designs. After each order, La Poste delivers the products to the customer's home or holds them for pickup at the post office.[45]

Since we issued our paper, La Poste has expanded in-store 3D printers to a total of six post offices. Beyond just printing in-store and offering a catalog of 3D printed products, La Poste now offers consulting services to help refine customers' designs, which could help small businesses improve their 3D printed offerings.[46] In addition, La Poste

Figure 2: Foreign Posts' 3D Printing Services

FOREIGN POSTS EXPERIMENT WITH 3D PRINTING

Some foreign postal operators are experimenting with 3D printing. The Postal Service could consider exploring similar initiatives that might help grow awareness of the technology and associate the Postal Service with 3D printing in the minds of consumers.

La Poste – France	La Poste has used partnerships to offer a variety of 3D printing services. Through a partnership with Sculpteo, La Poste offers 3D printers in six post offices where customers can get prints of their own designs with the help of a consultant or choose from a selection of designs already available. It also partnered with UCKi to offer a service which turns children's drawings into jewelry. Finally, it partnered with CIRTES to create customized packaging for fragile or unusually-shaped items through 3D scanning.
Royal Mail – United Kingdom	Royal Mail ran a successful trial with iMakr to offer a 3D printer at a post office in London. Customers could create their own designs or choose an existing design from a catalog. Although the post office in London no longer has a 3D printer onsite, Royal Mail still offers an online catalog for customers to order various gifts and other items.
Swiss Post – Switzerland	With its partner my3Dworld, Swiss Post gave customers an opportunity to buy 3D miniature versions of themselves during a 3D printing "roadshow" that toured the country. Swiss Post also created a marketplace that focuses on selling 3D printers and printing supplies to the maker community, as well as some 3D printed jewelry and other small items.
Singapore Post – Singapore	As part of a new "innovation center," Singapore Post offers 3D printing services at its flagship "new generation" post office. Customers can print customized gifts or prototypes, as well as get their image 3D scanned and printed onto a small figurine.

44 Greg Bensinger, "When Drones Aren't Enough, Amazon Envisions Trucks with 3D Printers," *Wall Street Journal*, February 26, 2015, http://blogs.wsj.com/digits/2015/02/26/when-drones-arent-enough-amazon-envisions-trucks-with-3d-printers/.
45 OIG, *If It Prints, It Ships: 3D Printing and the Postal Service.*
46 La Poste, "Innover et créer des objets en 3D," http://www.laposte.fr/particulier/produits/presentation/innover-et-creer-des-objets-en-3d/(language)/fre-fr.

recently teamed with the Dutch company UCKi to offer a service that converts children's unique artwork into 3D printed jewelry. Figure 3 shows an example of this customized 3D printed jewelry.[47]

Figure 3: 3D Printed Jewelry from La Poste

Source: La Poste.

La Poste also partners with CIRTES (an engineering research center in France) to create fully customized packaging that protects fragile or unusually-shaped items during shipping. Through this process, which is available at a few post offices near Paris, La Poste takes a 3D scan of a customer's item and then a machine precisely cuts layers of durable packing materials, like cardboard, so that they exactly conform to the shape of the item.[48] With fully customized packing materials, items have substantial protection during the shipping process. Figure 4 shows an example of this customized packaging. The video at https://youtu.be/UqUzaLqzhN8 shows how La Poste and CIRTES create customized packaging through 3D scanning. Please note that the audio is in French.

Video 1: Pack&Strat

47 Alexandre Martel, "La Poste proposera désormais l'impression 3D de bijoux !," *3D Natives*, May 20, 2014, http://www.3dnatives.com/laposte-bijoux-imprimer-3d/.

48 CIRTES, "La Poste lance un service innovant de conditionnement 3D avec le CIRTES," http://www.cirtes.com/news/19-la-poste-lance-un-service-innovant-de-conditionnement-3d-avec-le-cirtes; La Poste and CIRTES, "La Poste Lance Un Service Innovant de Conditionnement 3D Avec le CIRTES," news release, July 15, 2014, http://www.cirtes.com/images/05_NEWS/2013/CP_2014_07_15.pdf; and Laurence Schmitt, "Pack & Strat l'emballage 3D arrive," *REGION*, http://www.republicain-lorrain.fr/actualite/2014/09/04/pack-strat-l-emballage-3d-arrive.

United Kingdom

In December 2014, Royal Mail started a 2-month trial program in which it partnered with the 3D printing company iMakr to place a 3D printer at a post office in London. Customers could select to have designs printed from the iMakr website at MyMiniFactory.com, or could bring in their own designs for printing. The products could be printed at the post office or an iMakr store, as well as delivered by Royal Mail. Through this partnership, Royal Mail made 3D printing services convenient and accessible for businesses and customers who might otherwise be unable to afford their own 3D printer.[49]

The 2-month trial program was considered a success, and Royal Mail still offers an online catalog of 3D printed products for customers to order. The available products include reproductions of historical artifacts and archaeological objects, smartphone cases, office supplies, and other items.[50] Figure 5 shows a magnet being 3D printed that depicts a historical stamp with Queen Elizabeth II's profile.[51]

By all accounts, the partnership has been mutually beneficial for Royal Mail and iMakr. Royal Mail found a partner with existing knowledge and experience related to 3D printing, so it did not need to develop those resources itself. iMakr benefited because such a high-profile partnership brought significant attention to 3D printing and made people aware of the types of products they could order or create. Because 3D printing is not yet fully in the mainstream of public consciousness, any increase in awareness can help the growth of the industry and the value of customizable goods.[52]

Figure 4: Layers of Cardboard Sheets Cut into Customized Shapes to Fit Uniquely Shaped Glassware by Pack&Strat

Source: Pack&Strat® Original 3D Packing patented process by Stratoconception® et Stratoconception®, Pack&Strat®, registered Software, Brands and Patents - Claude Barlier - CIRTES - Saint-Dié-des-Vosges – France.

Switzerland

In late 2014, Swiss Post entered a partnership with the 3D printing company my3Dworld. Together, they opened an online marketplace and organized a 3D printing "roadshow" across the country that gave customers the opportunity to buy 3D printed

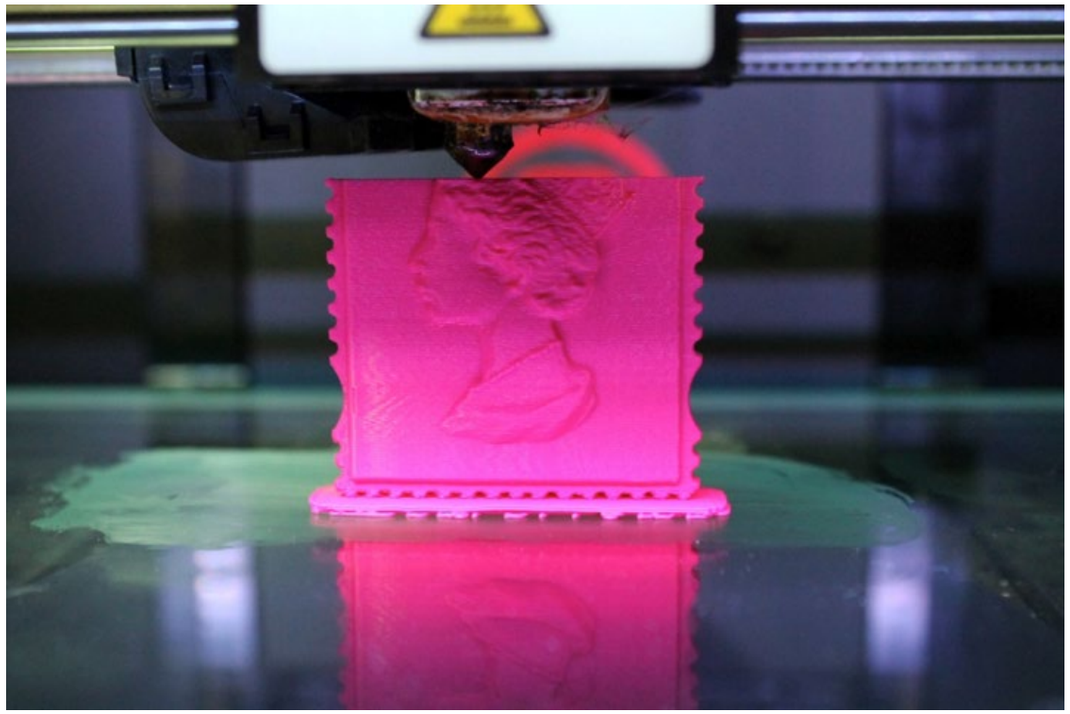
49 Michelle Matisons, "Royal Mail Teams With iMakr for In-Store 3D Printing & Delivery," *3dPrint.com*, December 8, 2014, http://3dprint.com/29015/royal-mail-3d-printing-imakr/ and Victoria Turk, "The UK Postal Service Is 3D Printing Stuff So It Can Deliver It," *Vice*, December 8, 2014, http://motherboard.vice.com/read/the-uk-postal-service-is-3d-printing-stuff-so-it-can-deliver-it.
50 Royal Mail, "3D Printed Products," https://shop.royalmail.com/gift-shop/3d-printed-products/icat/3dproducts.
51 The stamp using this image was first issued in 1967. For more information, please see http://www.royal.gov.uk/MonarchUK/Symbols/Stamps.aspx.
52 iMakr representative, in discussion with the authors, June 10, 2015.

miniature replicas of themselves. Unlike the initiatives of other posts, the Swiss Post marketplace primarily focuses on selling a wide range of 3D printers, many different types of printing filaments and other supplies, a 3D scanner, and other items useful for customers to do their own printing.[53] While it also offers some 3D printed jewelry and miniature figurines, the general goal of Swiss Post's initiative appears to be meeting the needs of the country's maker community.[54]

Singapore

Singapore Post has recently introduced several "new generation" post offices that strive to meet evolving customer demands in the digital age. These locations offer high-tech services like 24/7 fully automated lobbies, tablets that let customers browse a wide range of products and start their transactions before they approach the counter, a business solutions center for local enterprises, and other features. Singapore Post describes these revamped post offices as "lifestyle hub[s] for traditional and essential services."[55]

Figure 5: A 3D Printed Historical Stamp Figure from Royal Mail



Source: MyMiniFactory.

At its flagship new generation post office, Singapore Post also offers 3D printing services. Customers and business owners can go to that post office to print out customized gifts or prototypes, or get their image 3D scanned and printed onto small figurines. The 3D printing and scanning services are part of an "Innovation Center" at that post office, which serves as a community maker space and fuels creativity.[56]

Suggestions for the Postal Service

The Postal Service should continue to observe the 3D printing market as it further develops, learn from the examples of foreign posts and logistics companies, and examine the potential of 3D printing to the extent allowable under its existing statutory authority. Doing so would help the Postal Service to position itself to meet the emerging 3D printing needs of citizens and businesses. According to observers of the industry, transportation companies have often waited to see what changes new technologies bring, instead of trying to anticipate the change by positioning themselves accordingly.[57] With 3D printing, the opportunities may be far too good for the Postal Service to wait and see before responding.

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53 Davide Sher, "The Swiss Mail Is Going 3D," *3d Printing Industry*, November 13, 2014, http://3dprintingindustry.com/2014/11/13/swiss-post-3d-printing/; "Swiss Postal Services Die Post explores 3D printing as a new source of revenue," *3Ders.org*, November 13, 2014, http://www.3ders.org/articles/20141113-swiss-postal-services-die-post-explores-3d-printing-as-a-new-source-of-revenue.html; and Swiss Post, https://www.postshop.ch/en/Highlight/3D-Print.

54 Alexandre Martel, "En Suisse, les bureaux de poste se mettent à l'impression 3D," *3D Natives*, November 14, 2014, http://www.3dnatives.com/suisse-poste-impression-3d/.

55 Singapore Post, "SingPost Rolls Out New Generation Post Offices," news release, October 3, 2014.

56 Ibid.

57 PwC Strategy&, "2015 Commercial Transportation Trends."

Identify Models Based on the Experiences of Foreign Posts

Now that a growing number of foreign posts have started offering various 3D printing services, they provide valuable models that the Postal Service could potentially emulate. In addition, the offerings from UPS and major retailers show that 3D printing has broad appeal and applicability. There are a number of opportunities the Postal Service could consider, including but not limited to the following:

- Establish a reverse logistics service to handle recycling and processing of 3D printed goods, so that materials can be reused for future printing.

- Provide 3D printing materials and other support services for small businesses and makers in neighborhoods where there is demand, or potentially online. Given that 3D printing for consumers and small businesses is an emerging market, no organization has yet established itself as the go-to provider for a wide range of printing materials at many locations across the United States. These locations need to be both convenient to customers and appropriate for storing 3D printing materials under the right conditions.[58] This could be a tremendous opportunity for whoever manages to provide an effective solution. However, it is important to note that it could be quite expensive to maintain a stock of a wide range of 3D printing materials at every location.

- Offer 3D printing services inside post offices, similar to the offerings of La Poste and UPS, potentially by partnering with a company that already has experience with 3D printing. Such a partner could help the Postal Service with, or cover entirely, the initial investment needed to roll out 3D printing services. A partner might also be able to help the Postal Service stay up-to-date with technological and other advancements in the quickly changing 3D printing industry.

It is important to keep in mind that the Postal Accountability and Enhancement Act of 2006 (PAEA) prohibits the Postal Service from offering new non-postal services.[59] Some 3D printing services, including those offered by other posts, may not be permissible under the Postal Service's current authority.[60] However, the Postal Service could make a case to the Postal Regulatory Commission (PRC) that some services — such as customized packaging created through 3D scanning — are ancillary to its existing offerings.[61] The potential for substantial new annual revenue from increased package shipments of 3D printed goods, as identified in the OIG's July 2014 paper, speaks to the benefit of the Postal Service establishing a role in the industry.

Serve as a Community Maker Space

As another possibility, the Postal Service could consider using room in its facilities to provide community maker spaces built around 3D printers. Libraries, universities, and other public institutions around the country have already started to experiment with such offerings, sometimes by teaming up with major 3D printing companies. For example, the State University of New York, New Paltz, worked with MakerBot to build an Innovation Center on campus with dozens of 3D printers. Students and staff can use the 3D printers to expand their skills and knowledge in arts, science, engineering, and other areas. Artists and other community members can also enroll in a digital design program that utilizes the center.[62] At the Public Library of Cincinnati and Hamilton County,

58 For example, some 3D printing materials are sensitive to excess humidity.
59 The Postal Service can only provide non-postal services (including products) that were offered as of January 1, 2006. See 39 U.S.C. § 404(e)(1-3). The law defines "postal services" as "the delivery of letters, printed matter, or mailable packages, including acceptance, collection, sorting, transportation, or other functions ancillary thereto." A postal "product" is defined as "a postal service with a distinct cost or market characteristic for which a rate or rates are, or may reasonably be, applied." See 39 U.S.C. § 102(5), (6).
60 For instance, some international posts currently offer 3D printing services that the Postal Service may not be permitted to provide under its existing authority. While the Postal Service generally has broad latitude to rent space to third parties who provide non-postal services, approval from the Postal Regulatory Commission (PRC) or congressional action may be required for the Postal Service to directly provide 3D printing-related services to the public. See 39 U.S.C §§ 401(e)(5), 404(e)(2).
61 There is no guarantee that the PRC would approve the Postal Service's request to offer such services.
62 MakerBot, "Customer Success Stories: SUNY New Paltz MakerBot Innovation Center," http://pages.makerbot.com/suny-new-paltz-case-study.html and "MakerBot Stories: University Gets First Innovation Center," June 25, 2014, http://www.makerbot.com/blog/2014/06/25/makerbot-stories-university-gets-first-innovation-center.

community members can access 3D printers as well as sewing machines, laser engravers, cameras, audiovisual equipment, and other tools to support their creative activities.[63]

The Postal Service has a presence in every community across the United States. In addition, it has more than 60 million square feet of excess space nationwide, much of which is in mail processing centers.[64] Some estimates find that effective 3D printing maker spaces can be set up for less than $10,000.

Understand the Shipping Needs of 3D Printing Companies

When a consumer orders a 3D printed product, it can sometimes take weeks before it arrives on their doorstep. This often depends on the type of material used for printing. The total time can be even longer if there are failed prints. It may be worthwhile for the Postal Service to reach out to 3D printing companies to learn more about their shipping needs and to identify potential solutions that could help minimize the time it takes to get products in consumers' hands. For example, in our 2014 white paper, we suggested that 3D printing facilities located at or near shipping nodes like postal facilities could help reduce shipping time.

Consider Offering Postal-Themed 3D Printed Goods or Designs

The Postal Service could look into whether it can sell 3D printed goods or designs based on postal artifacts or history. It has a long and rich archive of images and memorabilia that it could draw upon for this purpose. For example, there may be antique stamp designs that would make interesting 3D printed pieces, similar to the 3D printed Queen's Head Stamp sold by Royal Mail.[65] If the Postal Service wanted to offer postal-themed 3D printed items, it would need to determine whether it holds the copyright for the original work in question.[66]

Conclusion

3D printing technology promises to shake up the manufacturing and logistics industries, shifting production closer to consumption and potentially revamping vast parts of the global supply chain. These changes will make fast, on-demand service and last-mile delivery more and more important in coming years. Meeting these growing demands represents a major opportunity in delivery and logistics. The Postal Service could play an important role in the future of 3D printing, given the complementary nature of its nationally distributed processing facilities and last-mile delivery network, and the localized nature of 3D printed manufacturing.

Logistics companies and foreign posts are actively partnering with 3D printing companies as a way to meet new customer needs while positioning their organizations to be beneficiaries of a 3D printing revolution. Others are experimenting with 3D printing services tailored for business clients with clear shipping or logistics needs. It makes sense for the Postal Service to consider similar initiatives. As the Postal Service looks to the future, anticipating the 3D printing needs of citizens and businesses will be critical, especially as it pertains to the new logistics needs that the technology is creating. 3D printing technology will soon fundamentally change the logistics industry, and this is the right time for the Postal Service to start associating itself with 3D printing in the minds of the public.

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63 Public Library of Cincinnati and Hamilton County, http://www.cincinnatilibrary.org/main/makerspace.html.
64 OIG, "21st Century Post Office: Opportunities to Share Excess Resources," December 5, 2011, http://www.uspsoig.gov/blog/21st-century-post-office-opportunities-share-excess-resources.
65 As mentioned above, PAEA may restrict the Postal Service from offering some 3D printing services.
66 Most of the time, the Postal Service should be able to offer items based on works the Postal Service created itself. Works the Postal Service has commissioned or licensed, however, would likely be another matter. To offer 3D printed items based on those works, the Postal Service would likely need to seek specific permission from the appropriate copyright holder, unless there was already an agreement in place that made reproductions permissible.

Appendices

Click on the appendix title to the right to navigate to the section content

Appendix A: Federal Agencies Have Found Innovative Uses for 3D Printing

NASA's 3D printers could eventually construct everything from small tools to deep space habitats.

Many federal agencies have benefited from the use of 3D printing. In particular, the Department of Defense has shown great interest in the technology, deploying 3D printers across its service branches. The U.S. Navy is currently working on around 70 3D printing projects hosted at dozens of its sites. It also uses a 3D printer onboard at least one ship, the U.S.S. Essex, to print various small items it needs, from oil tank caps to organizational tools. Defense manufacturers including Lockheed Martin, Aerojet Rocketdyne, and General Electric are working to improve the ability of 3D printing to create parts suitable for the military to use in weapons, ships, and vehicles.[67]

Defense manufacturers like these, other high-tech manufacturers, universities, and various companies with financial interest in 3D printing, including UPS, have established a nonprofit organization called the National Center for Defense Manufacturing and Machining (NCDMM). The organization's goal is to develop and promote advanced and cost-effective manufacturing tools for defense suppliers, including 3D printing.[68] NCDMM also manages America Makes, a public-private partnership of federal agencies, manufacturing companies, and universities similarly devoted to developing and accelerating the use of 3D printing across government and the manufacturing sector.[69] Federal agencies' work on 3D printing through partnerships like these demonstrates strong belief that the technology holds great promise for advanced manufacturing and for helping to meet agencies' supply needs.

In addition, NASA recognizes the potential of 3D printing to decrease the cost and risk of meeting its mission supply needs. Its work with 3D printing is still in the early stages, but continued research and experience with 3D printing will allow NASA to give its astronauts more autonomy and flexibility on their missions. NASA has deployed a 3D printer on the International Space Station, where it has already demonstrated that astronauts can use 3D printing in microgravity conditions to build small tools and parts in ABS plastic. Once NASA has determined that these goods are suitable and safe for astronauts to use on missions in space, 3D printers will be a ready source of these tools and parts, reducing the high costs of sending spares on missions to space.[70] Long-term missions will benefit even more from in-space manufacturing, which could eventually construct everything from small tools to deep space habitats. NASA and America Makes are currently holding a competition to design and build a 3D printed habitat for deep space exploration, including a journey to Mars.[71]

The Department of Energy's (DOE) Oak Ridge National Laboratory, a member organization of America Makes, has demonstrated the ability to create large objects in advanced materials with 3D printing. Its Big Area Additive Manufacturing Machine (BAAM) has the ability to print in carbon fiber-reinforced ABS, an advanced material suitable for aerodynamic vehicle frames. The laboratory demonstrated the capability by creating a replica Shelby Cobra automobile for display at the 2015 Detroit Auto Show. Researchers with the lab constructed the vehicle's frame and body with the BAAM, and have found that the carbon fiber-reinforced ABS exhibits strength and stiffness comparable to or better than the steel or aluminum often used for the frames and bodies of automobiles. According to DOE, this capability makes the BAAM suitable for many research applications for clean energy manufacturing, not just for automobiles.[72]

Additionally, the Critical Materials Institute at DOE's Ames Laboratory is using advanced laser-based 3D printing technology to develop new metal alloys to replace rare-earth elements and other materials needed in critical technologies, including clean

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67 Marcus Weissgerber, "The Defense Industry Is Expanding the Use of 3D Printing," *Defense One*, September 29, 2014, http://www.defenseone.com/technology/2014/09/defense-industry-expanding-use-3d-printing/95396/.
68 "About," National Center for Defense Manufacturing and Machining, http://ncdmm.org/about/.
69 "About America Makes," America Makes, https://americamakes.us/about/overview.
70 NASA, "3D Printing In Zero-G Technology Demonstration (3D Printing In Zero-G)," http://www.nasa.gov/mission_pages/station/research/experiments/1115.html and "International Space Station's 3-D Printer," https://www.nasa.gov/content/international-space-station-s-3-d-printer.
71 NASA, "NASA's Centennial Challenges: 3-D Printed Habitat Challenge," http://www.nasa.gov/directorates/spacetech/centennial_challenges/3DPHab/index.html.
72 Department of Energy, "3D Printed Shelby Cobra, http://energy.gov/eere/amo/3d-printed-shelby-cobra and "Accelerating Innovation: We Do It Together," http://energy.gov/eere/amo/accelerating-innovation-we-do-it-together.

energy systems. The institute's 3D printer, which uses the heat of a laser to fuse metal powders, will allow its researchers to produce a large number of different metal alloys far more quickly than they could with traditional casting methods. In a demonstration, researchers used the printer to produce a small rod made out of stainless steel in just 20 seconds. The speed at which the 3D printer can generate a library of alloys for testing makes it a powerful tool for the Critical Materials Institute as it continues its work on energy innovation.[73]

The ability of 3D printing to decentralize production of objects manufactured with high levels of precise detail has applications for more public facing government services as well. In 2014, the National Institutes of Health (NIH) and the Department of Health and Human Services launched the NIH 3D Print Exchange, a program that provides biomedical models formatted for 3D printers and offers tools for users to create and share such models. Prior to the launch of this program, few scientifically accurate or medically applicable 3D-printable models were available, as researchers in the field lacked the ability and tools to generate them. The program provides these tools, and now hosts over 5,000 3D-printable files of biomedical models on the first government-sponsored website devoted to 3D printing. As 3D printers become increasingly accessible and affordable, this free, readily available library of biomedical models will help facilitate research, medical practice, and education.[74] Additionally, in January 2015, the NIH's National Institute of Allergy and Infectious Diseases made 3D technologies, including 3D printing, the subject of its annual Bioinformatics and Computational Biosciences Festival, demonstrating that NIH sees great potential to improve the field of medicine through the increased use of the technology.[75]

73 Ames Laboratory, "3-D Printer Speeds Metals Research," https://cmi.ameslab.gov/resources/success/success-3d-printing.
74 U.S. Department of Health and Human Services Idea Lab, "The NIH 3D Print Exchange," http://www.hhs.gov/idealab/projects-item/the-nih-3d-print-exchange/ and National Institutes of Health, "About the NIH 3D Print Exchange," http://3dprint.nih.gov/about.
75 National Institute of Allergy and Infectious Diseases, "Science in 3D," https://respond.niaid.nih.gov/conferences/Bioinformatics2015/Pages/default.aspx.

Appendix B: Summary of OIG's July 2014 White Paper on 3D Printing and the Postal Service

In its July 2014 white paper, the OIG focused on two general scenarios of the potential future of 3D printing, ways the public would have access to it, and how the Postal Service could play a major role in its continued development. In the first scenario, people would buy finished 3D-printed goods from online retailers. In the second scenario, people would print some items using in-home or desktop printers. These scenarios are relevant to the Postal Service because it could ship both finished 3D-printed goods from retailers and materials to people doing 3D printing themselves.

To assess the potential effects of these scenarios, the OIG hired Laurits R. Christensen Associates, an economic consulting firm with in-depth knowledge of postal operations. Christensen Associates analyzed commercial package data from fiscal year 2013 (October 1, 2012 to September 30, 2013), focusing on industries and parts of the supply chain that would likely be affected by increased levels of 3D printing, such as the market for toys, electronics, jewelry, and auto parts.

The figure below summarizes how the two potential 3D printing revolution scenarios could affect the Postal Service. Each scenario results in an increase in annual revenue due to increased package shipments. The scenarios are not mutually exclusive, as it is easy to envision a world in which people buy some 3D printed finished products from businesses while also printing some items at home. The estimates given in the figure show the range of potential annual revenue growth, depending on how much 3D printing disrupts the status quo.

3D PRINTING COULD BE A POSTAL BOON

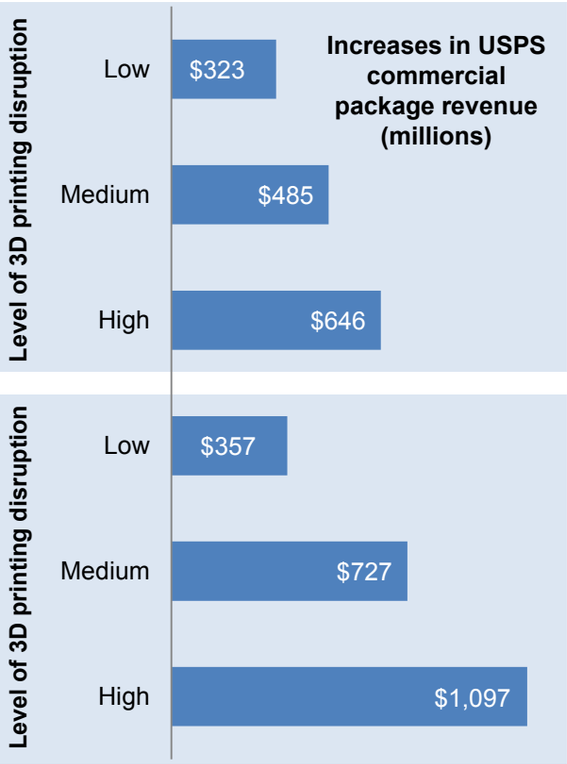
Under two potentially simultaneous scenarios, a 3D printing revolution could lead to more shipments of small, lightweight packages — the types of packages the Postal Service specializes in handling. Depending on the scenario and level of disruption, 3D printing could boost the Postal Service's package revenue by $323 million to $1.1 billion per year. These estimates are based on 2013 package volume data.

USPS AS 3D PRINTING HUB

Small and regional businesses 3D print products at or near Postal Service shipping nodes before entering products seamlessly into the mail. These businesses would likely compete on speed, so streamlining deliveries could help them to better serve customers — while also boosting package volume for the Postal Service.

PRODUCTS PRINTED AT HOME

People use in-home 3D printers to produce many of their items, rather than buying final products from retailers. While this could reduce both deliveries of finished products and brick-and-mortar purchases, deliveries of printing materials could surge, potentially giving a boost to the Postal Service. This scenario could be very profitable, but a slew of uncertainties and potential risks make it highly unlikely.



Source: USPS OIG graphic based on data from Christensen Associates.

Centralized 3D Printing: Businesses Sell Finished 3D Printed Goods to Consumers

In the first scenario, consumers buy finished 3D printed goods from retailers, specialized businesses, or services bureaus. Those companies could end up increasingly competing on speed as the 3D printing market grows larger, leading some of them to locate their printing facilities at or near shipping nodes. Doing so would allow them to get their products into the delivery stream more quickly. The Postal Service could act as a logistics partner for companies located near postal facilities, in a sense becoming a hub for 3D printing. Under this scenario, the Postal Service's commercial package revenue could increase by as much as $646 million per year.

The Postal Service's benefit from 3D printing and its attractiveness as a logistics partner for 3D printing companies would come from the strength of its network. In this scenario, any weakening of the Postal Service's network — through reductions in important features like service frequency, number of delivery points, tracking and tracing services, or pick-up options — could result in lower additional new revenue from package shipments.

In addition, the Postal Service has more than 60 million square feet of excess space nationwide, much of which is in mail processing centers. These are industrial facilities that could accommodate the electrical power and ventilation needs of large 3D printers. The Postal Service could lease some of this space directly to 3D printing businesses, making it even easier for them to ship products quickly.

Decentralized 3D Printing: People Print Some Goods at Home Instead of Buying Them

The second scenario involves people using in-home or desktop 3D printers to print out a variety of items. Much of the buzz around 3D printing is based on this notion — that people will one day use affordable, high quality in-home printers to make many, if not most, of the items they now purchase from retailers. This is highly unlikely. If in-home 3D printers do manage to become ubiquitous, they would probably only be used for relatively few items. However, if people do end up using in-home 3D printers to create many things and not just a small handful of items, the result could be massive disruption to existing retail supply chains. It could lead to big cuts in brick-and-mortar and e-commerce sales, and a corresponding drop in the number of commercial packages shipped.

Even though products under this second scenario would be printed at home, those in-home printers would need a regular stream of 3D printing materials. After all, people could not print things at home without printing materials on hand. In addition, if people are printing many different types of items, they are going to need to stock a variety of printing materials. This all adds up to a significant increase in package shipments. Under this scenario, the Postal Service could see an increase in annual commercial package revenue as high as $1.1 billion if people 3D print many things at home.

Although there would be a drop in the number of finished goods being shipped by the Postal Service, this drop would likely be small because most household items are currently purchased at brick-and-mortar retail stores. In other words, shipments of printing materials would replace brick-and-mortar purchases that were not shipped through the Postal Service to begin with. The new shipments of 3D printing materials could more than make up for any of this small decrease. However, it is worth repeating that this scenario is not only unlikely, but also highly uncertain.[76]

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76 Even if in-home 3D printers become more commonplace, it remains to be seen how many things most people will actually print. In addition, people might buy printing supplies from physical retail locations.

The Postal Service Could Play an Important Role in 3D Printing

The 2014 white paper included several suggestions for the Postal Service to consider if it seeks to play a role in the 3D printing industry. For example, as the Postal Service continues to consolidate its processing network, it could guard against any changes that would lessen the value of its delivery network. The Postal Service could also establish a platform for 3D printing that uses its national retail network and last-mile delivery capabilities, potentially by partnering with companies that specialize in 3D printing.[77] Designs sent to the platform could be 3D printed and then shipped via same-day or next-day delivery. Customers could also order designs to be printed from an online marketplace and then delivered or held for pickup at a Post Office. Other ideas proposed in the 2014 white paper include ways that the Postal Service could use 3D printing to improve internal operations, and the use of 3D printing to create customized packing materials for individual items that are oddly shaped or otherwise unsuited for ready-made boxes and packing supplies.

77 As the 2014 white paper notes, the Postal Service would need to assess what services might be permissible under PAEA. See 39 U.S.C § 404(e)(2).

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