A5- 3D printing primer

3D printers build physical representations of digital models, using additive manufacturing techniques or manipulating lasers to bind materials. This is a diametric contrast to traditional manufacturing processes, which are fundamentally reductive and typically produce waste while casting, molding, forming, machining and joining a part. A 3D printer may create the same part in one smooth process with literally no waste.

The most common approach to 3D printing—fused deposition modeling (FDM)—prints different forms using plastics such as acrylonitrile butadiene styrene (ABS) and polylactic acid (PLA). Materials are heated to reach a melting point. Moving mechanically along two axes, an extruder layers the material down. It then shifts slightly higher and repeats the process.

For objects requiring overhangs, manufacturers can print with multiple materials, one of which supports the main structure and is easily removed in the finishing process. Other techniques, such as stereolithography and laser sintering, use lasers to precisely heat alloys or powders and make them into solid forms. These laser technologies may deploy various metals that cannot be handled with FDM. However, both plastic and metal materials for 3D printers have been achieving increasingly higher pressure and temperature thresholds, and many are stronger than previously engineered designs because they require no welds.

The market for 3D printers used to be quite small, because their primary use was rudimentary prototyping. However, new applications are continually appearing and prices are dropping commensurate with demand. In the near future, investments focused on adding speed, precision and capacity will allow 3D printers to create more complex products in larger volumes. The Department of Energy's Oak Ridge National Laboratory and machine tool manufacturer CINCINNATI® Incorporated recently announced a partnership that will seek to create a 3D printer with 200 to 500 times the speed, and 10 times the size, of most current printers. Moreover, several patents for technologies such as laser sintering will expire soon, thereby spurring additional innovation. Printers also are being combined with traditional subtractive manufacturing tools to produce metal parts that rival or surpass the quality of older techniques. Many of these can be produced with less material and in various weight-saving shapes. General Electric, for instance, is "printing" jet engine brackets that weigh 84 percent less than their predecessors.

1.

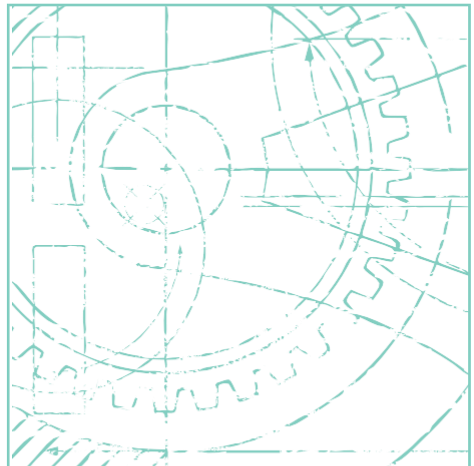
Rapid prototyping and mass customization

The traditional strength of manufacturing is making large amounts of identical or similar products with great speed and efficiency. Small runs and customized output have always been problematic. 3D printing completely changes this paradigm. Although not (yet) suited to high-volume production, 3D printing will change the economies of small-run manufacturing because no special molds, jigs or other tools are needed to produce a product. 3D printers simply accept the product's digital file and build the product—as many or as few as needed. This makes 3D printing an ideal tool for reinventing the prototyping process and taking mass customization to a new level.

Many industries already use 3D printers for prototyping—frequently saving time, garnering big savings and producing better products. Take the case of a consumer goods company that formerly required four days to produce a prototype for a single location. By placing 3D printers wherever its designers and engineers work—and linking them with sophisticated digital networks—the company can now create, compare, study and work from identical physical models. Each facility produces the same object locally, with feedback and design updates communicated and embedded seamlessly across locations. The result has been a 75 percent reduction in prototype creation time, with the lion's share of attention now focused on designing products instead of juggling prototypes and coordinating transport.

On the mass customization side, consider a hypothetical shopper looking for a new door handle. Until recently, the person's choices were probably limited to whatever pre-manufactured designs and shapes were available at various retail locations. However, by isolating the components of a door knob to the handle and the locking mechanism, it now is possible to mass manufacture the locking components but mass customize the handles. Professional designers or knowledgeable individuals may even upload their own designs to the loose equivalent of an app store, with the customer then viewing his or her alternatives and requesting individualized production of the chosen style wherever a 3D printer is available. The principal players are 3D printing technology coupled with the digital supply network, which stores, carries and helps interpret information.

The bottom line is that 3D printers help companies reduce the time and cost associated with prototyping parts and refining their design. 3D printers also make it possible to economically create one-of-a-kind products, thereby accommodating specific size and configuration requests and rounding out product lines by custom-making hard-to-find variations of a basic high-volume item. And as more companies build out their digital supply networks, the more designs can be shared across the enterprise, with designers, suppliers, manufacturers, logisticians, business partners and even customers working together to produce better products at lower costs.



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2.

New ecosystems for accommodating the digital nature of 3D printing

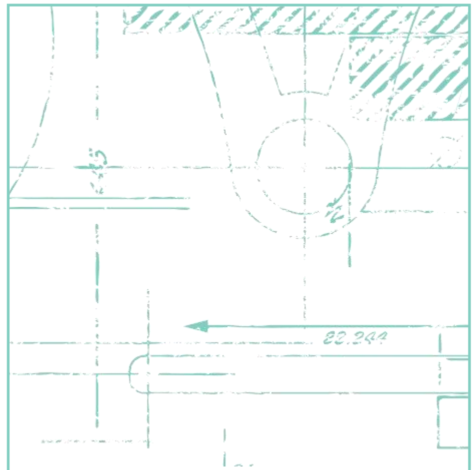
Digital technology is changing how products are designed, made, assessed, purchased and consumed. Most everyone recognizes this fact. However, the implications for strategy, quality, security, support and even monetization are far muddier.

One of the most daunting questions is how digital supply networks will evolve, given digital's ability to figuratively link designers, suppliers, manufacturers, logisticians and consumers. We know the potential for disruption is enormous: Think what digital has done for (or to) the publishing, music, photography and telecommunications industries. Music, for example, used to have a physical form (a record, tape or CD). Now, most music is translated into a digital format and an entire digital supply chain has emerged: from design (composition) to recording to distribution to consumption.

Digital's opportunities match or exceed its disruptive potential. With more parts cataloged digitally, an organization is better positioned to collaborate within and outside the enterprise. In 3D printing, for example, a single connected platform can bring suppliers, logistics providers and manufacturers together to share design files, make faster decisions, create new and potentially better parts, and accelerate production and delivery times. Significant new economies are equally feasible—the result of innovative part designs, lower shipment volumes and costs, more production-sourcing opportunities, and (as noted earlier) economical mass customization.

With proper digital rights management technology, proprietors of the new ecosystem also can be confident their intellectual property is protected. And once parts are produced, advanced scanning technologies can help ensure product quality. Lastly, the digital supply network can become a channel for ad-hoc, contract-based manufacturing relationships that help companies reduce risk and respond rapidly to demand shifts and spikes. After all, 3D printing makes it simpler to make items—or the spares and components an item requires—very close to the time when, and location where, they are needed.

Taking full advantage of these innovations can require a largely new "manufacturing digital ecosystem" that supports new ways to design and produce products, and makes it possible to share design content so that satellite businesses, third parties and even customers can produce items themselves. Within this scenario, organizations might use 3D printing to help customers develop ultra-tailored products. Perhaps that customer wants to remodel a house to suit a certain era in Spanish history: Designers and contractors—working anywhere—could collaborate with the customer to prototype, perfect and ultimately "print" windows, doors, hardware and even materials .



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3.

New angles to driving operational excellence

The ability to create parts and products on demand could fundamentally alter companies' approach to operations. In many industries, 3D printing could drive down the volume of finished goods shipments. In turn, the nature and destination of raw materials shipments might change dramatically. Businesses will have to figure out which products (or parts of products) can be printed and, accordingly, what manufacturing, assembly and shipment options need to be reinvented. It's not unlikely that the entire relationship between companies and third parties could shift: Logistics services providers might offer customers 3D printing services at centralized warehouse locations connected to their shipping facilities. So instead of shipping a product from Cleveland to Seattle, a manufacturer might sell the rights to the digital model to a logistics company, which then prints the product in Seattle and delivers it to the customer. This scenario is a textbook (albeit advanced) example of postponement.

3D printing and digital supply networks offer many ways to rethink how supply chains support postponement. One might be to develop a just-in-time parts-replacement strategy. As manufacturing equipment ages, it becomes more difficult to maintain fully stocked warehouses of spare parts—especially because suppliers may not have kept all their original designs and molds. 3D printing, enabled by DSNs, can help alleviate the problem by letting companies produce parts only when they are needed, thus eliminating outages and reducing the amount of capital that sits unused in a warehouse.

For instance, instead of asking a supplier to build a custom part to fix a broken machine or disabled vehicle, a customer might purchase the blueprint CAD diagrams for the required part and (using a 3D printer) build it himself. Along with speeding up delivery and reducing costs, this could mean that obsolete or hard-to-find parts are suddenly available. Like using DNA to revive an extinct species, 3D printers could bring out-of-production parts back to life by scanning a worn out but still-needed dinosaur and "printing" a new one.

The obvious benefit is minimized downtime. However, inventory-related advantages may also be extensive because almost every SKU has a finite shelf life or simply reaches a point when storing it is no longer worth the physical space it takes up. Operating a facility stocked with digital printers instead of parts—accompanied by a digital system that receives and stores model files—could give companies economical, fingertip access to a huge variety of parts that are created only as needed. Imagine a manufacturer or logistics services provider that operates a fleet of planes, trucks and vans. If one of its vehicles breaks down, the capacity of the fleet is temporarily reduced. However, a deal with the vehicle's manufacturer—allowing the company to source the part's 3D model data—could reduce the downtime period to whatever is needed to "print" and install the replacement part.

The first step toward building an internal parts-postponement program is understanding what parts might be viable candidates. This is done by pulling data such as "cost to manufacture" and "manufacturing lead time" from a product lifecycle management (PLM) system and then performing a printability assessment. The assessment would look at part specifications and the ability of available printers to reproduce those specs. Critical parameters might include dimensions, material types, and necessary operational pressures and temperature thresholds. The effort will result in an initial list of potentially printable parts. Other opportunities could be revealed by quantifying the advantages 3D printing has over subtractive techniques (e.g., increased speed to delivery, lower logistics costs, improved quality) and then exploring the use of new materials and designs. A good example is General Electric, which is reengineering its jet engine fuel injectors for 3D printing as a single component, instead of the 20 individual pieces that were previously assembled.[10]

3D printing's effect on WIP and finished goods highlights a similar, operations-related benefit: sustainable manufacturing. Today, if a retailer receives an overly large shipment of, say, vases , the retailer must sell at a deep discount or return the vases to the manufacturer—thus increasing someone's labor and transportation costs, and exacerbating CO_2 problems. However, both outcomes are avoided if operations have been reengineered so that vases are printed as needed at a local shipping facility or retail location. Mechanisms also would exist so that raw materials could be repurposed to other products at any time, or used to create design variations that are more marketable. Either way, waste is avoided, shipment volumes are reduced and the environment is a bit happier.