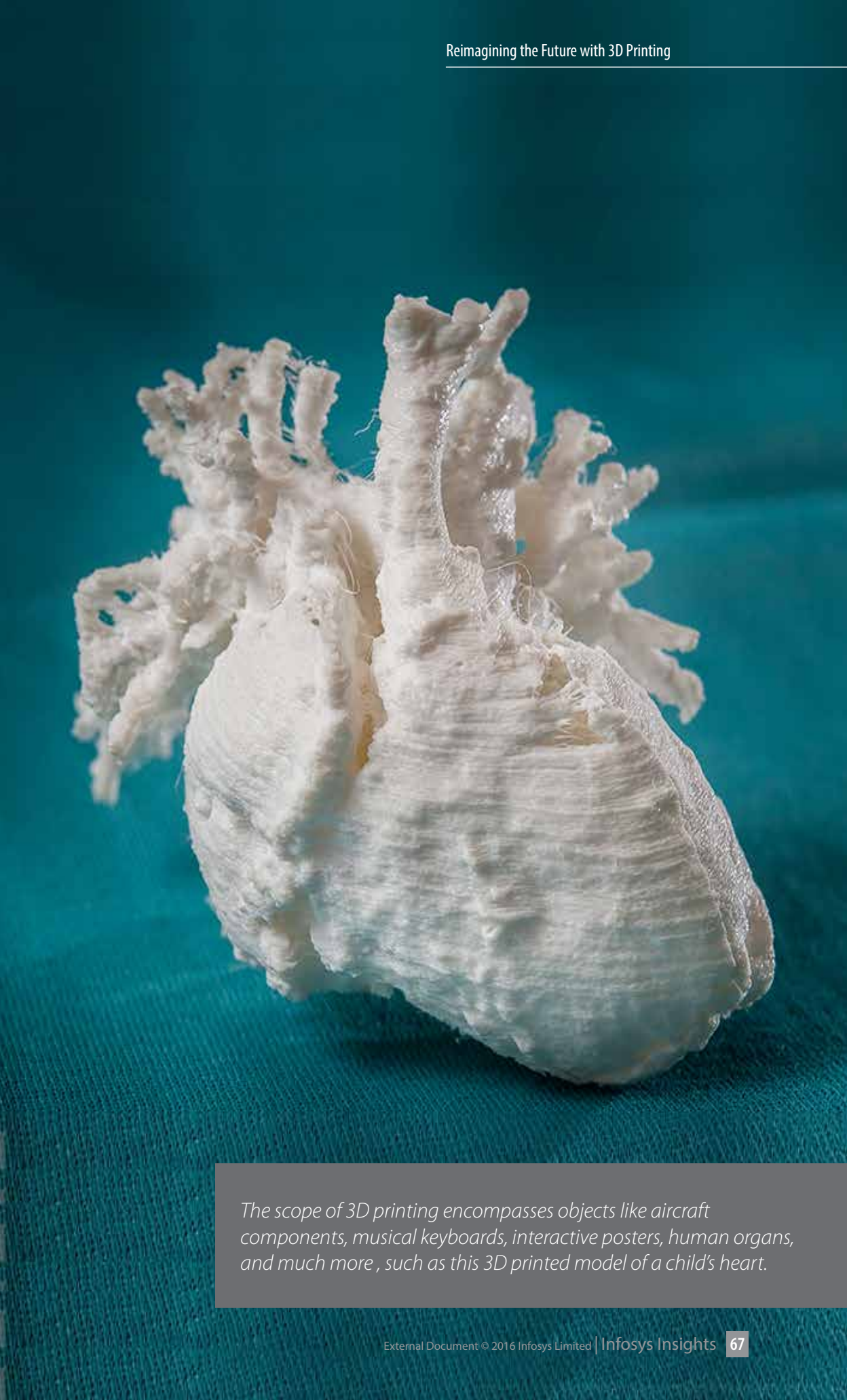
REIMAGINING THE FUTURE WITH 3D PRINTING

3D printing opens up a universe of possibilities in manufacturing — from low-cost manufacturing to a lean approach to design and development. This think piece explores the journey of this technology and what it could mean for our future.

Around the turn of the 20th century, manufacturing was perceived as the 'old economy.' The new economy seemed like a whole new world, inhabited by enterprises with a digital DNA. However, the onset of the Industrial Internet of Things (IIoT) changed this perception, with binary bits and physical atoms merging to alter the manufacturing landscape, paving the way for a 'maker movement.' And at the epicenter of this movement is three-dimensional printing or 3D printing; transforming manufacturing, engineering, industrial design, and hardware. It has the potential to upend industries and change lives — imagine consumers printing superfoods with a specific calorific value or doctors printing prosthetic limbs to correct deformities!

3D printing is making a dent in niche areas, but not across traditional manufacturing. The trajectory of most technologies follows an uncharted, but predictable journey: The technology becomes mainstream after multiple catalysts encourage its adoption by a critical mass of users. Take for instance, personal computing, whose acceptance was low when it presented itself as an alternative



The scope of 3D printing encompasses objects like aircraft components, musical keyboards, interactive posters, human organs, and much more , such as this 3D printed model of a child's heart.

to mainframe computers. Similarly, at the outset of the electric vehicles movement, electric cars appealed only to a small number of consumers, with the majority of vehicles running on gasoline.

"For me, the 'tipping point' isn't about how many manufacturers have changed, it is about how many minds have. Thanks to more accessible technology, we are now reaching a critical mass of people who, when they think about how things are made, think in a different way. You could say that they are thinking in 3D," says T. J. McCue in the Harvard Business Review. McCue leads the GoExplore3D project, tracking the growth of 3D printing technology in the US.

Also known as additive manufacturing, 3D printing is making rapid strides with the confluence of the Internet of Things, artificial intelligence, big data analytics, advanced simulation and modeling, industrial biology, and quantum computing. The scope of 3D printing encompasses objects like aircraft components, musical keyboards, interactive posters, human organs, and much more. In fact, 3D printing is even salvaging our heritage: 3,000-year-old Assyrian artworks and Hatra sculptures that were vandalized in the Mosul Museum, Iraq, are being recreated using 3D printing.

Distributed manufacturing allows extreme customization and low-volume production of products.

The impact of 3D printing has surprised Charles (Chuck) Hull, who invented stereolithography printing and cofounded 3D Systems to commercialize the technology. "Although I expected 3D printing to be embraced by manufacturers, I could never have anticipated how widespread 3D printing is today, or the types of things that people are doing with it. For the past 30 years, we have had the distinct pleasure of watching our innovation spur more innovation," said Chuck, on being honored by the American Society of Mechanical Engineers (ASME).

A digital crossover

3D printers create moving components and can manage a wide range of substances — from recycled materials and rare earth metals to biological matter. The technology transforms manufacturing by enhancing versatility across various industry segments, including aerospace, automotive, consumer goods, chemical, defense, healthcare, infrastructure, and utilities.

Thanks in large measure to an ecosystem — a network of networks — with near real-time interfaces across products, manufacturing systems, assets, and stakeholders, 3D printing is now a part of the mainstream. Today, it redefines the way consumer and industrial products are designed, developed, and delivered. This technology improves product performance dramatically by supporting new materials, novel designs, and innovative functionality. It positions organizations at Zero Distance to customers, by facilitating production at the point of purchase / consumption and diluting the advantage of economies of scale.

Distributed manufacturing allows extreme customization and low-volume production of products. 'Normal,' a New York City-based startup, uses 3D printing to make premium earphones. Customers place an order via an app after sharing images of their ears and specifying their preferred color. The earphones are printed, assembled, and shipped from the Normal office-cum-factory-cum-store in less than 48 hours.

Global manufacturers are adopting 3D printing to simplify production and enhance the quality of their products. GE established the Center for Additive Technology Advancement (CATA) in Pennsylvania to innovate across business lines, including aviation, healthcare, oil and gas, power, renewable energy, and transportation. Today, it has an 'industrialization lab' to optimize 3D designs and simulate production.

Software designs hardware

Data, simulation techniques, and algorithms lie at the heart of additive manufacturing. A 3D printer processes intricate designs from 3D-scanned images and/or Computer-Aided Design (CAD) files and renders it in different

materials. The software can be tweaked to personalize the design for a customer or adapt the product to a specific market / requirement. What is more, the agility of 3D printers rationalizes the cost of production, as a single printer can be used to print different objects as well as parts for diverse applications. Boeing uses 3D printing to make components for different aircraft models.

Additive manufacturing accelerates product development by eliminating the dependence on design / product specialists for prototyping. It minimizes the cost for mass customization as well as bespoke offerings. Thus, by leveling the playing field, it minimizes capital investment and mitigates the risks associated with new product launches. More importantly, it encourages product companies to serve niche market segments.

In addition, 3D printing minimizes the complexity in product design and development. A 3D-printed car has roughly 40 parts, as against 20,000 parts in an assembled car. NASA is exploring 3D printing to generate food for manned space missions in partnership with 'Made in Space,' a Silicon Valley startup. It follows the successful launch of Made in Space's zero-gravity 3D printer at the International Space Station to print spare parts and components.

The concept of 'open design' — akin to 'open source' in software — will be adopted to collaborate for the manufacture of physical products and components. Designs will be co-created and enhanced, ensuring superior and cost-effective products. In several areas, 'open design' will render independently designed products obsolete, a prime example being how Wikipedia is preferred to the Encyclopedia Britannica by users. Shapeways, a 3D printing factory, depends on 'open design;' wherein customers create their own products, seek inputs from experts for unique designs, or select from a curated list of

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designs uploaded by users. Shapeways offers over 50 materials, including sandstone and precious metals, to print ordered objects.

A shift in the manufacturing ecosystem

3D printing will create new paradigms in manufacturing. It will disrupt traditional methods and provide business opportunities to early adopters. Further, the technology will change the character of the manufacturing landscape and its extended supply chain in the following ways:

- Distribution centers may become obsolete, as it makes more economic sense to facilitate production powered by 3D printing as close as possible to the place of consumption
- 3D printing lowers the entry-level barrier in manufacturing by avoiding huge capital investments. It could spur the emergence of a new breed of manufacturing enterprises, similar to the Internet, creating a new genre of companies like Amazon
- The process of manufacturing will become more agile. One 3D printer can manufacture a diverse range of products, ranging from an aircraft part to an automotive component
- Manufacturers can achieve a high level of customization for each product. The concept of 'engineer to order' will become mainstream in manufacturing
- Crowdsourced design or 'open design' will pave the way for better quality products. GE is collaborating with Snecma S.A., a French aircraft and rocket engine manufacturer, to develop fuel nozzles for jet engines through additive manufacturing. The printed fuel nozzle is lighter and more durable than the manufactured version
- A new breed of collaborative enterprises will emerge with the mass adoption of 3D printing. For example, 3D Hubs, an online 3D printing services platform, connects 3D printer owners with customers. The network offers services in more than 20,000 locations around the world. Engineers and designers choose service providers based on their proximity and specific materials. The forum enables owners of 3D printers to maximize their capacity utilization, while providing access to 3D production

3D is taking another big leap towards 4D printing, a term coined by Skylar Tibbits, director of the Self-Assembly Laboratory at the Massachusetts Institute of Technology.

Green by design

3D printing inherently has a modest carbon footprint as it consumes less energy. At the same time, it ensures above-par product quality and productivity. Manufacturers can ensure sustainability across the product life cycle (from extraction of raw materials to disposal of the used product) and safeguard the environment as well as community health.

In conventional subtractive manufacturing, approximately 80 percent of the material is machined out. Additive manufacturing offers a leaner alternative, by depositing the exact amount of material required, thereby ensuring zero wastage. Additionally, green and low-cost materials can be used as feedstock for printing. WinSun Decoration Design Engineering Co., a Chinese construction company, used a mixture of recycled construction waste, cement, and fiber glass to 3D print multi-storeyed buildings.

Logistics and after-sales services are set to be transformed by on-demand manufacturing. Product companies may not require regional warehouses, distribution centers, and stockists. In-house 3D printers and printing service providers may replace subcontractors and suppliers of parts and accessories. Transportation and inventory costs may become insignificant in the on-site manufacturing supply chain.

The next orbit of 3D

3D is taking another big leap towards 4D printing, a term coined by Skylar Tibbits, director of the Self-Assembly Laboratory at the Massachusetts Institute of Technology.

It involves printing objects that respond to stimuli such as impact, temperature, and moisture. Research in self-transforming printed products may culminate in the wings of an aircraft adjusting to aerodynamic conditions, or shoes shrinking and soles responding to the wearer's gait.

While advances in digital and computing technology have shone a light on 3D printing, the shop floor requires reinvention in order to successfully and efficiently assemble 3D-printed parts. "It takes a long time to get all of the functionality into the system, at a level of robustness and availability that people expect in traditional subtractive equipment; but again, that is just the normal growth and learning phase of any new technology," says Roger England, director of materials science and technology, technical quality, and intellectual property at Cummins Inc., in an interview with the American Society of Mechanical Engineers (ASME).

In a landscape of seismic changes, manufacturers need to address some fundamental questions such as:

- What are the implications of product safety when you deliver digital designs and not the end product? Which party / stakeholder is responsible for the warranty of the product?
- Would a manufacturer perceive itself as an assembler rather than a manufacturer in the future? Will the factory of the future be an assembly line for 3D printed parts?
- What are the business implications of delivering digital designs rather than products? Should manufacturers adopt the publishing industry model of a major print run of 3D parts or print on receiving orders?
- How do manufacturers create an ecosystem for design collaboration within and beyond the enterprise?
- What should be the focus areas of investment – building the ecosystem, or reinforcing manufacturing capabilities?

About the Author

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