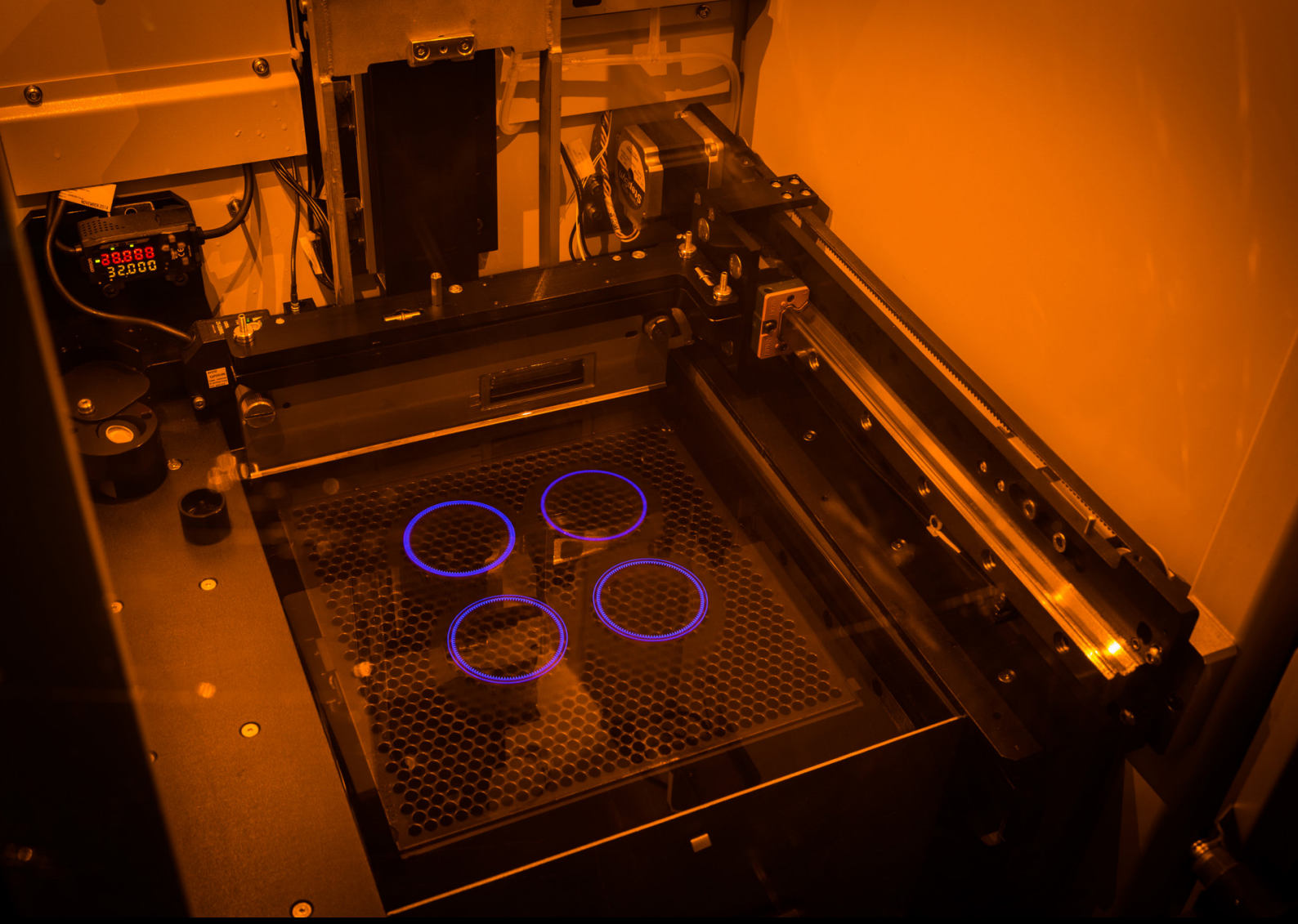

3D Printing Trend Report 2023

Market insights and forecasts in additive manufacturing

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PROTOLABS Manufacturing. Accelerated.

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Key findings

The uptake of 3D printing in manufacturing is continuing to grow, with more engineers using 3D printing more frequently and for higher volume orders. This signals that its evolution from a hobbyist technology to an industrial manufacturing solution is only gaining momentum. Further fueling its mainstream adoptions, new innovations in composites, AI and shape-morphing systems are presenting new potential applications.

$19.9bn

in predicted 3D printing market growth in 2023, an increase of 17%

83%

of respondents believe 3D printing helped them save substantial costs in their manufacturing pipeline

56%

of survey participants named FDM the most frequently used additive technology

76%

of businesses produced 10+ parts in their production runs, up from 49% in 2021

71%

of businesses surveyed used 3D printing more in 2022 than in 2021

Table of contents

From fiction to fabrication

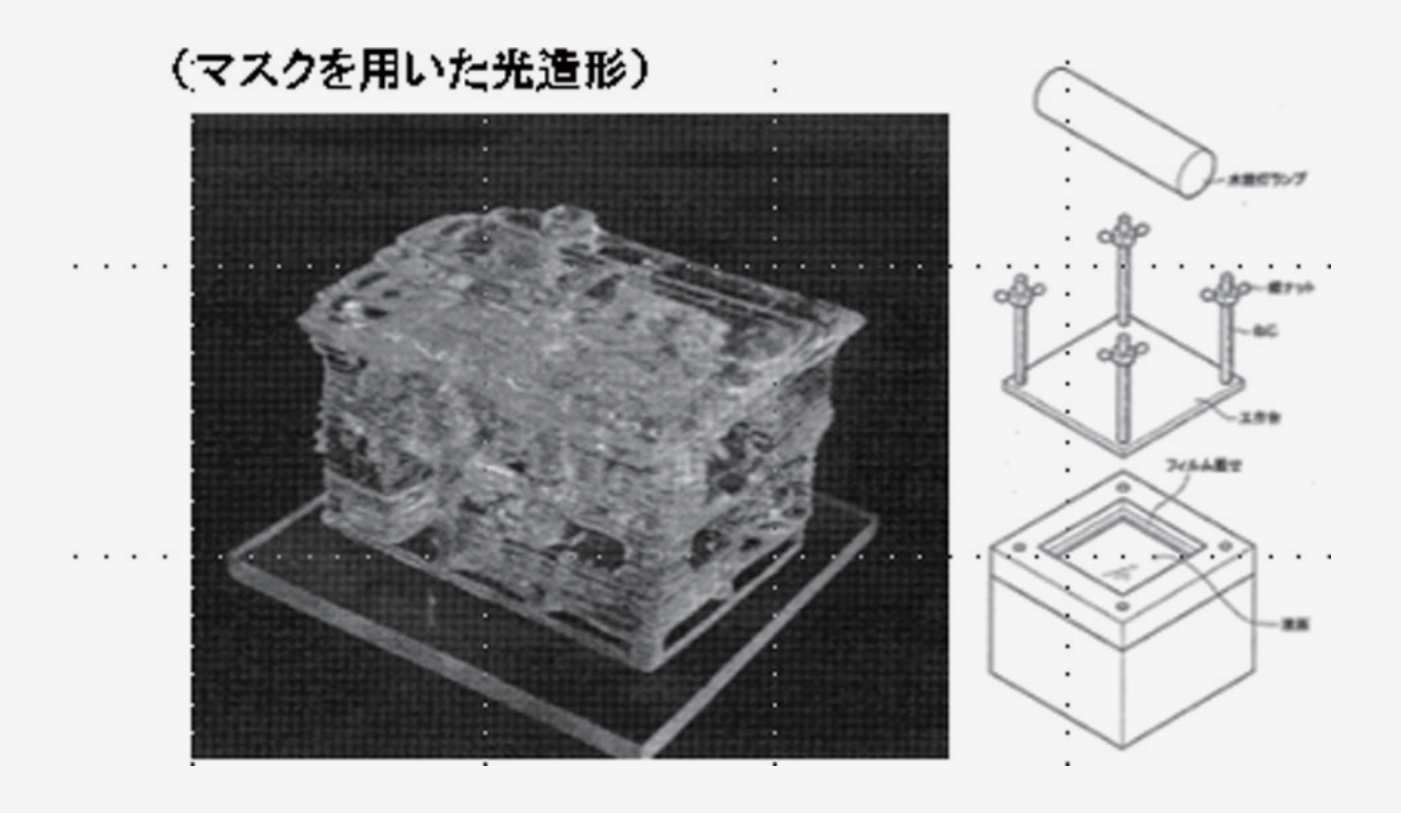
A brief history of 3D printing

Our 2023 report explores the latest trends and advancements in 3D printing technology, touching upon the market growth and future projections. We will also discuss the current applications of additive manufacturing (AM), identify the key industries that rely on this technology, and delve into its future prospects. Furthermore, we will examine the impact of 3D printing on sustainability. But first, let's take a brief journey through the history that has shaped this innovation.

Many scientific innovations have roots in science fiction, and 3D printing is no exception. The earliest concept resembling modern additive manufacturing appeared in a 1945 short story by William Fitzgerald Jenkins (pen name Murray Leinster) called "Things Pass By." The tale described a machine that created objects from magnetronic plastics, planting the seeds of 3D printing in the minds of the general public.

Several decades later, in the early 1970s, Johannes F. Gottwald filed the first patent for a process called liquid metal recorder.[01] The concept involved producing objects from liquified metal, which solidified layer by layer.

In 1980, Dr. Hideo Kodama expanded upon Gottwald's idea by proposing the use of thermosetting polymers instead of metal.[02] He also suggested using ultraviolet (UV) light to cure photopolymers, a process now known as stereolithography (SLA). Dr. Kodama filed a patent application for his UV curing-based rapid prototyping technique in Japan, but was unable to secure a patent internationally.



Hideo Kodama's early patent of a house fabricated by 3D printer, image via IEICE

Charles Hull later filed a patent for SLA in 1986. His company, 3D Systems Corporation, released the world's first commercially available 3D printer, the SLA-1.[03] In addition to this landmark achievement, Hull also invented the STL file format still in use today.

By the late 1990s and early 2000s, 3D printing began to demonstrate potential in various industries including bioengineering. What made 3D printing truly mainstream, however, was Adrian Bowyer's RepRap Project, which launched in 2005.[04] Short for Replicating Rapid Prototyper, RepRap's objective was to develop a machine capable of building most of its own parts, making the technology more accessible and affordable.

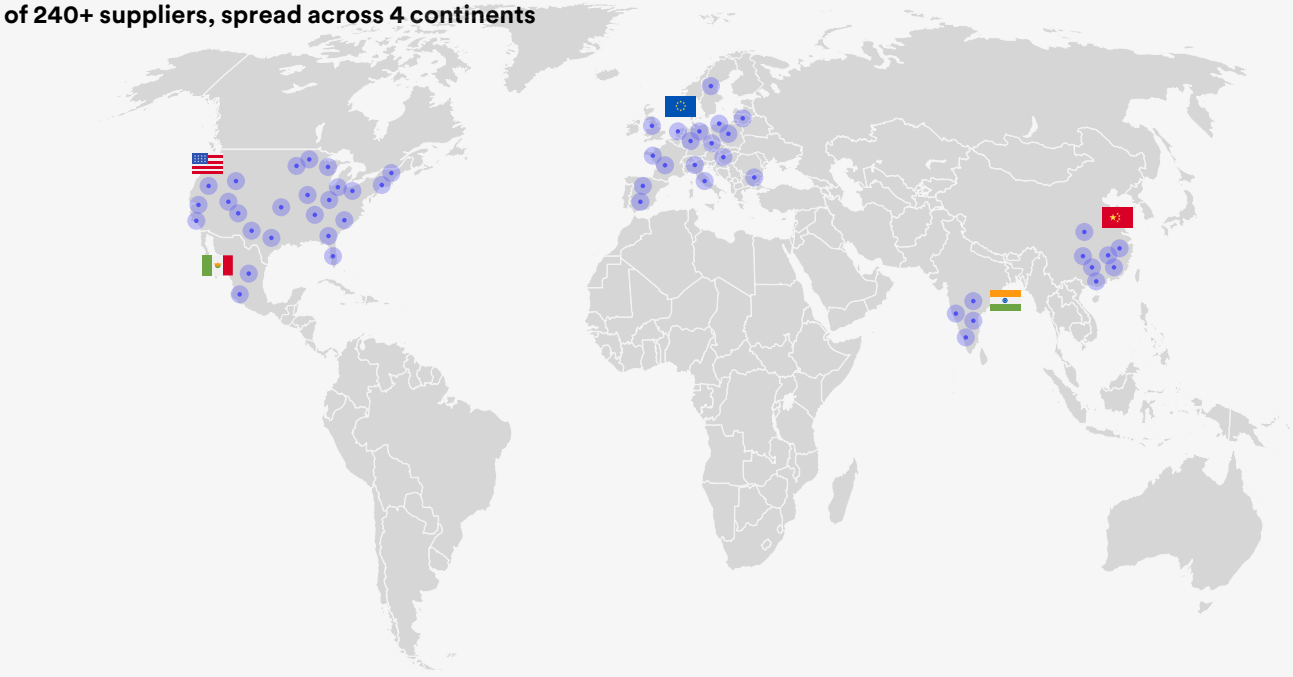
The outcome was the RepRap 1.0 Darwin machine, which could print several of its own components required for the assembly. This breakthrough made 3D printing accessible to hobbyists, researchers, and small businesses alike.

The expiry of key 3D printing patents, starting with Fused Deposition Modelling (FDM) in 2009 and followed by Selective Laser Sintering (SLS) and SLA in the 2010s, led to accelerated growth and development in the additive manufacturing industry. The elimination of licensing fees reduced printer development and production costs, allowing more companies to enter the market and spurring competition and innovation.

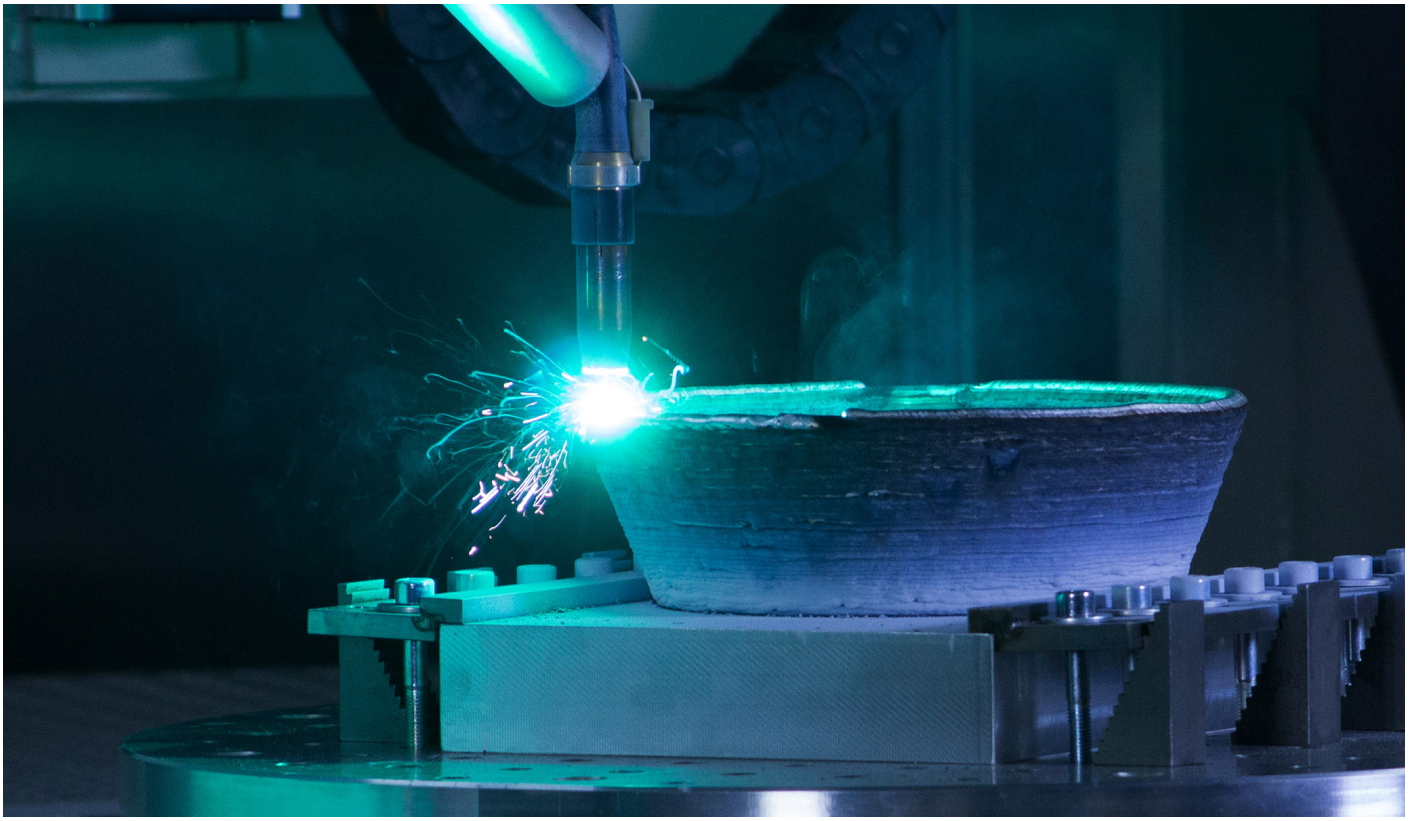
As ownership of desktop 3D printers grew, Bram de Zwart, Brian Garret, and Filemon Schöffer founded 3D Hubs in 2013.[05] The online platform connected people requiring 3D printing services with local printer owners. Users could upload their 3D models to the platform and have them produced at affordable prices. As more professional engineers used the platform for product development, the business rebranded as Hubs and pivoted to connecting mechanical engineers with a qualified network of manufacturing partners to provide broader capabilities.

Today, additive manufacturing is a mature technology, with steady growth in consumer interest and industrial applications. Recent advancements in 3D printing focus on refinements such as speed, scale, efficiency, cost reduction, and sustainability, which we will cover in the next section.

Hubs' distributed manufacturing network is made up of 240+ suppliers, spread across 4 continents



Recent technology trends and advances in 3D printing



WAAM 5-axis wire arc additive manufacturing for large metal parts, image via GEFERTEC

Starting with hardware advancements, there have been significant developments in the large-format metal AM space. For instance, SLM Solutions is building a laser-powder bed fusion (LPBF) system with a 1.5-meter Z-axis[06] for the US Air Force, which will use multiple lasers to produce large-scale metal parts and could become the largest laser fusion-based printer. Large-scale composite specialist Caracol is also developing a near-net-shape metal wire arc additive manufacturing (WAAM) system, which uses metal wire feedstock and a robotic welding arm to create large structures or repair metal parts.[07]

There are also new developments in extrusion technologies; Belgian startup Sculpman has patented a variable nozzle. It uses a rectangular nozzle hole, which can be adjusted to control the layer width throughout the build, resulting in faster deposition rates without compromising quality.[08]

Looking next at materials, there is an ever-growing variety of engineering thermoplastics and resins, composites, polymer powders, and metal powders. Electrostatic discharge (ESD) resins are opening up applications in electronics, damping elastomer resins in wearables, and flame retardant materials in transport and other industries.

Software developments are driving forward many of the major technology milestones in 3D printing. In FDM, there have been breakthroughs in non-planar printing, with GCODE generation software enabling the printing of curved lines to minimize ladder effect, eliminate supports for overhangs, and improve vertical strength.[09]

In an industrial context, automation is top of mind. Print speed, quality, and consistency are advancing thanks to greater process automation, including slicer optimization, smart part orientation, batch layouts, and post-processing. Workflow automation is also vital and there are a growing number of software solutions that link and automate the various stages in the 3D printing production chain. A fully automated workflow ultimately enables lights-out 3D printing, with factories that require little to no human supervision.

Broadly speaking, 3D printing has experienced something of a reverse evolution of sorts; starting off as a mostly hobbyist and DIY technology, the technology is now maturing and realizing its industrial potential.

Direct metal laser sintering (DMLS) is capable of 3D printing complex and organic part geometries in a range of metal materials

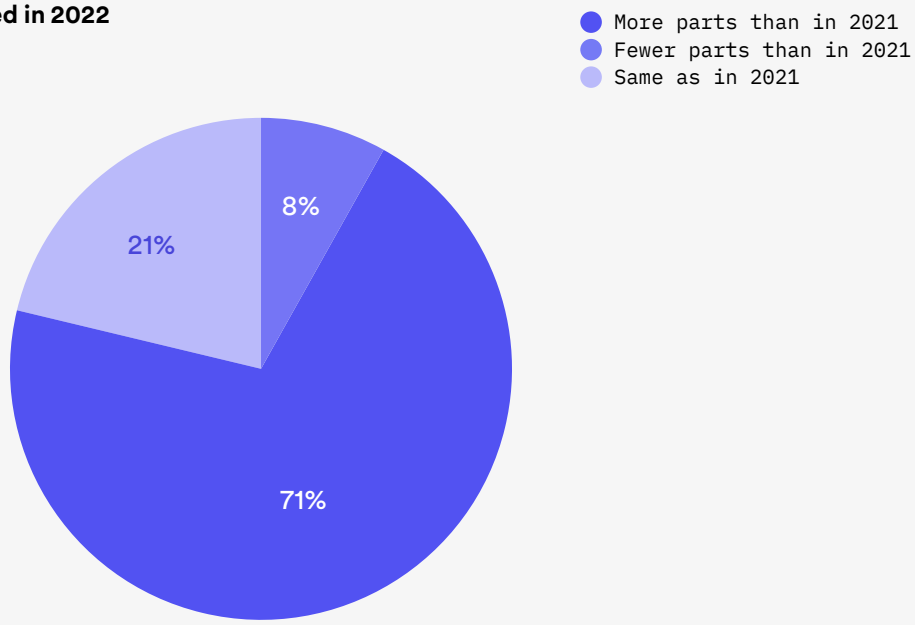
3D printing market growth and predictions

In 2022, the average estimated market size, which included revenue from 3D printing systems, software, materials, and services, reached $17 billion at an annual growth rate of 13%. Our previous report had predicted a market size of $18.3 billion with an annual growth rate of 21%, based on our internal intelligence and averages of the CAGR projections from the industry's top 10 market analyst firms.

Bear in mind that most market analyst firms do not report data on an annual basis. As a result, their 2023 predictions still rely on a CAGR of 21%. However, considering that the growth in 2022 was less robust than we initially anticipated, we have adjusted our 2023 predictions to reflect a revised annual growth rate of 17%. Based on our calculations, we now forecast a market size of $19.9 billion for 2023.

Our most recent survey from February 2023, involving 1,035 participants, highlights the market growth. The majority of respondents, 71%, revealed they 3D printed more parts in 2022 than they did in 2021, while only 8% printed fewer parts during the same period.

Figure 1: Quantity of parts 3D printed in 2022



Q: How many 3D printed parts did you source/produce in 2022?
Source: Hubs survey, conducted February 2023, n=1035

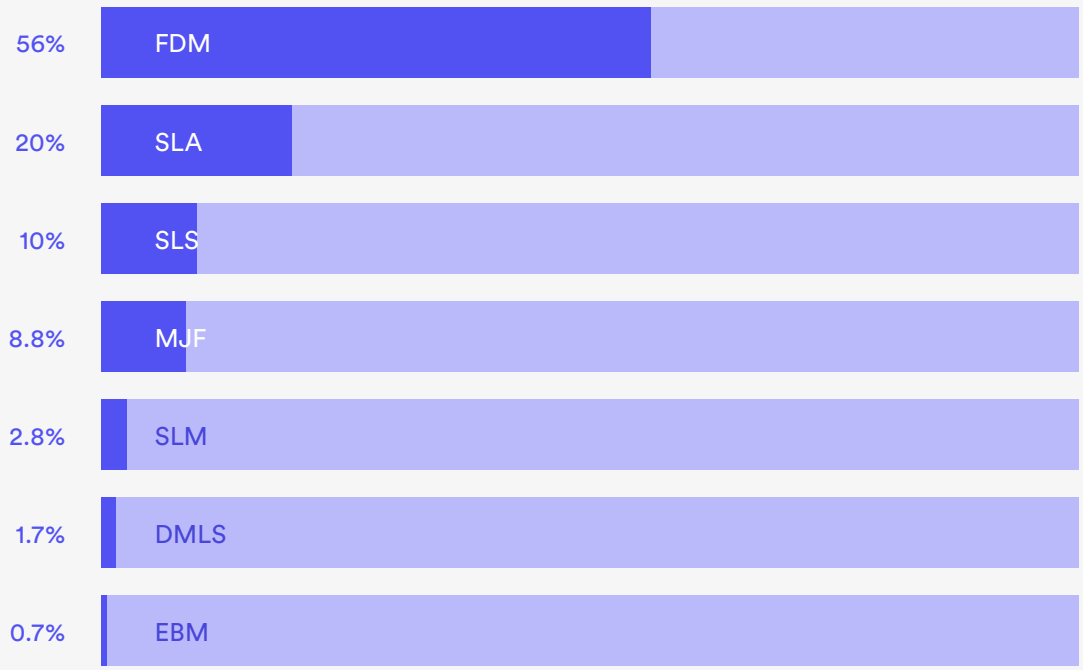
Polymer and metal 3D printing updates

According to the latest report from AM Power, the industrial metal additive manufacturing market experienced a growth of over 20% in 2022 and was valued at more than €3 billion.[10] The technology is predicted to grow even further in the coming years with a compound annual growth rate (CAGR) of nearly 30% until 2027.[11] Meanwhile, the polymer AM market is expected to grow at an annual rate of approximately 13%, with a starting value of EUR 6.5 billion in 2022.

Despite the faster growth in the metal AM market, the polymer AM market still generated over twice the revenue compared to its metal counterpart. This trend is reflected in our survey as well, with polymer 3D printing processes clearly taking the lead over metal 3D printing technologies.

Within each of these printing technologies, the advancement of post-processing options is helping drive adoption. Polymer 3D printing, including SLA and SLS, often requires a process like vapor smoothing to improve the surface finish. An additional post-processing step is also often critical in metal 3D printing. In a recent survey, global digital manufacturer Protolabs learned more than two-thirds of DMLS customers required some level of surface finishing on their parts. Protolabs acquired Hubs in 2021 to offer an even more comprehensive online manufacturing solution to engineers, including a variety of post-processing options.

Figure 2: Most favored 3D printing method



Q: Which 3D printing method do you primarily use for part manufacturing?
Source: Hubs survey, conducted February 2023, n=1035

“3D printers have evolved to accommodate large part sizes, fast speeds and a growing library of materials that fit a variety of applications, but post-processing is often a necessary step to strengthen or improve the cosmetic appearance of parts,” Protolabs Applications Engineer, Eric Utley said. “Fortunately, the innovation we are seeing in these downstream processes is becoming both more effective and automated, greatly increasing the scale of the additive industry.”

3D printer market updates

Market analysis firm CONTEXT reported a notable increase in 3D printer revenue, even though global shipments declined by 4% during the same period.[12] The research organization attributes the 14% rise in system sales revenue during Q3 2022 to inflationary pressures that led to price increases across all categories, bolstering revenue. In contrast, the firm discovered that unit shipments, particularly sub-$2,500 “personal” 3D printers, dropped significantly due to demand and supply chain issues. Despite the overall growth in revenue, CONTEXT reported only a modest 2% increase in industrial shipments between Q3 2021 and Q3 2022, with metal units rising by 4% while polymer machines declined by 2%. This trend of high revenue and low-volume sales is predicted to persist through 2023.

SLS printers at Protolabs' additive manufacturing facility in the U.S.

3D printing's impact on key industries

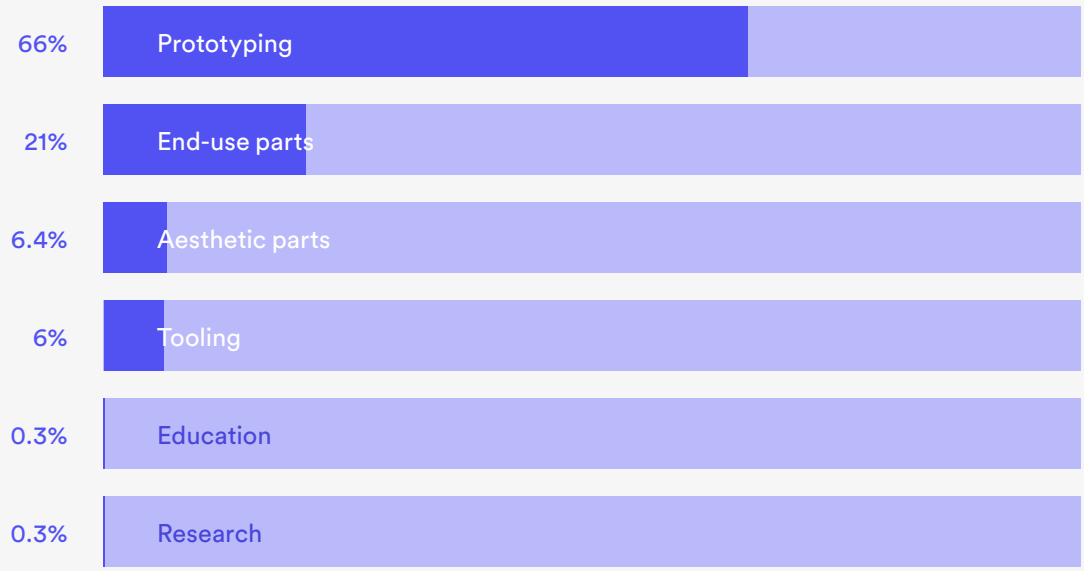
This section highlights the primary applications of 3D printing and the key industries that have embraced this innovative technology. By examining how various sectors have integrated 3D printing into their operations, we can better understand its versatility and potential for future growth.

Main applications for 3D printing

1. Prototyping
Developing a sample product to assess design and functionality before full-scale production was the first real use for 3D printing, and still represents a significant share. In our survey, 66% of respondents said they use 3D printing for prototyping because it helps speed up product development times. New designs or features can be iterated, tested, and validated with greater agility.

2. Tooling
Tooling involves creating specialized equipment for production. With its ability to produce tools, jigs, fixtures, and assembly aids on demand, 3D printing can enhance conventional production lines by minimizing machine downtime, increasing production agility, and unlocking custom solutions. At its facility in Poland, for example, Toyota has reaped the benefits of using AM for tooling, citing agility, faster lead times, and design freedom as the three main benefits.[13]

Figure 3: Top 3D printing applications



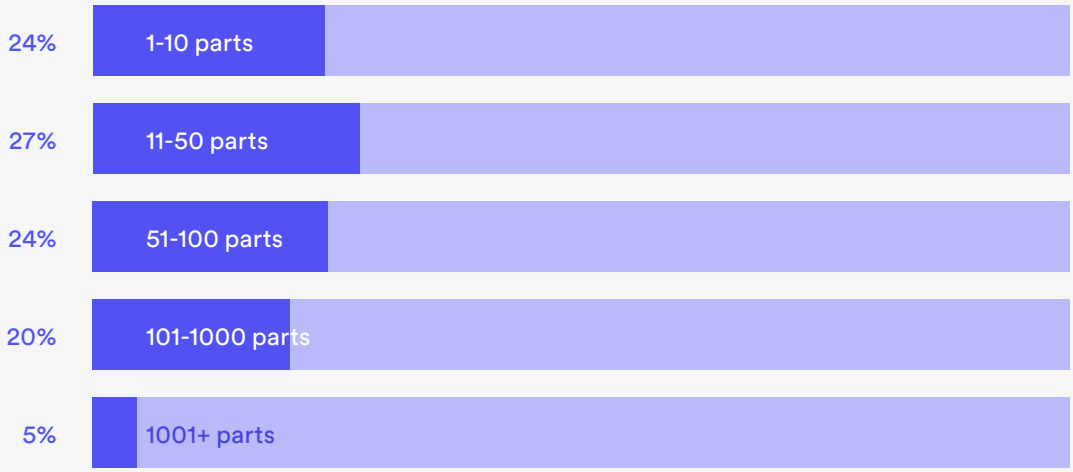
Q: What's your main use for 3D printing?
Source: Hubs survey, conducted February 2023, n=1035

3. Low-volume production
When producing a limited number of units meant for niche markets, 3D printing presents an economically viable method. It empowers manufacturers to offer limited-edition products and spare parts production, all while minimizing costs typically associated with inventory and storage. Toyota also uses HP 3D printing to print replacement parts on demand as well as short-run end-use components.[14]

4. Mass customization
For mass customization, where products are tailored to individual customers without compromising high output levels, 3D printing is the ideal manufacturing method. CAD files can be modified depending on customer needs and printed in batches for efficient and custom production. Dental aligner molds are a perfect example of this.[15] Tech startup Formify also uses 3D printing to produce custom ergonomic computer mice based on images of the customers' hands.[16]

4. Serial production
Serial production is a process of creating multiple identical products, in succession, for high efficiency. As workflows are increasingly digitalized and automated, it is easier for manufacturers to produce parts round-the-clock. In 3D printing, serial production is especially viable for small parts because several of them can fit into a single build. For example, Protolabs leverages a fleet of 150 3D printers, turning out as many as 1 million parts per year for its clients.

Figure 4: Size of 3D printing production runs



Q: What was the size of your 3D printing production runs in 2022?
Source: Hubs survey, conducted February 2023, n=1035

Metal 3D printers line the factory floor at Protolabs

Primary industries

1. Aerospace

Aerospace was among the first adopters of additive manufacturing. The technology's propensity for low-volume production as well as its design freedom have created opportunities for aerospace OEMs over the years. One of the primary reasons aerospace manufacturers have been so enthusiastic about 3D printing is that it allows them to produce more lightweight components, which improve aircraft fuel efficiency. Jet engines, structural aircraft parts, and interior cabin components are just some of the parts that 3D printing is used for today.

Aerospace components can undergo design optimization, and larger assemblies can be consolidated into fewer parts. 3D printing also empowers aerospace OEMs to accelerate development and production cycles, eliminating the need for tooling by directly producing functional end-use parts in metal or engineering-grade polymers.

Aerospace maintenance, repair and overhaul (MRO) providers are also turning to AM to improve operations. In 2022, GE Aviation's Loyang facility in Singapore became the first MRO site to receive approval for using metal additive manufacturing to repair commercial jet engine components, reportedly cutting repair times in half.[17]

2. Automotive

The implementation of additive manufacturing in the automotive industry has evolved substantially over the last three decades. Today, various 3D printing processes are used for rapid prototyping, tooling, customization, spare-part manufacturing, and series production.

Automotive manufacturers, including BMW, GM, Ford, Volkswagen, and Mercedes-Benz, have benefited from 3D printing. Some have found revenue opportunities by bringing to market exclusive luxury products. The Cadillac CELESTIQ, unveiled in late 2022, is an "all-electric, ultra-luxury flagship" that integrates 115 3D printed end-use components. It is hailed by GM as its most technologically advanced Cadillac vehicle.[18] Bentley Motors recently became the first automotive brand to 3D print solid gold details for the Batur.[19]

There is also a growing automotive trend to explore 3D printing for serial mass production. This is enabled by advances in digitalized workflows and automation. BMW participated in the IDAM project, which successfully built fully automated production lines driven by metal 3D printing. These production lines are capable of turning out 50,000 components per year.[20] The successful pilot project demonstrates AM's potential for industrial, high-volume production for automotive.

3. Medical

3D printing has helped to advance diagnostic and treatment solutions in the medical sector. Today, the technology is used in the production of patient-specific implants, prosthetics, surgical guides and instruments, anatomical models, dental products, and more. Additive manufacturing allows for easy customization (with a patient's medical scans being translated into printable models) and can be used for point-of-care production.

The technology provides a high degree of agility. In Ukraine, for instance, there are efforts underway to deliver much-needed 3D printed custom implants, suture anchors (used for re-attaching soft tissue, like tendons or ligaments, to bone), and other medical instruments to hospitals on the front line.[21]

In the dental segment, 3D printing is now well integrated—particularly vat polymerization, which accounts for 60% of the dental 3D printing share.[22] Dental and orthodontist labs rely on technology to produce custom crowns and bridges, dentures, implants, surgical guides, and more. Many of the leading clear aligner brands use 3D printing to create custom molds for their clients' aligners rapidly.[23]

Five industries 3D printing is driving forward

There is potential for 3D printing in all industries, but some have been keener adopters than others. Here are five industries that are exploring 3D printing and are on the cusp of transformation.

1. Food
3D printed food has been around for quite some time: printed pizzas, chocolate, and candy laid the groundwork for what is happening in the field today. The technology, which is being adapted for printing meat substitutes as well as cultivated meat, has enormous potential for reducing reliance on intensive animal farming. Printed food could also be embedded with custom nutrient profiles to benefit medical patients or the elderly.

2. Fashion
3D printing's impact on fashion is gaining traction, particularly in footwear. Adidas famously brought running shoes with 3D printed midsoles to market,[24] but they are not the only company pushing the boundary. At Paris Fashion Week 2023, multiple 3D printed shoes were featured on the runway (Reebok x BOTTER[25], Maison Dior[26]). Beyond footwear, there are also explorations of 3D printed textiles led by designers like Julia Koerner, Anouk Wipprecht, and Bastian Müller. In fashion, 3D printing enables greater design freedom, customization, local production, and less material waste.

The Met Gala 2019 featured a 3D printed dress by Zac Posen in collaboration with Protolabs and GE Additive

3. Motorsports

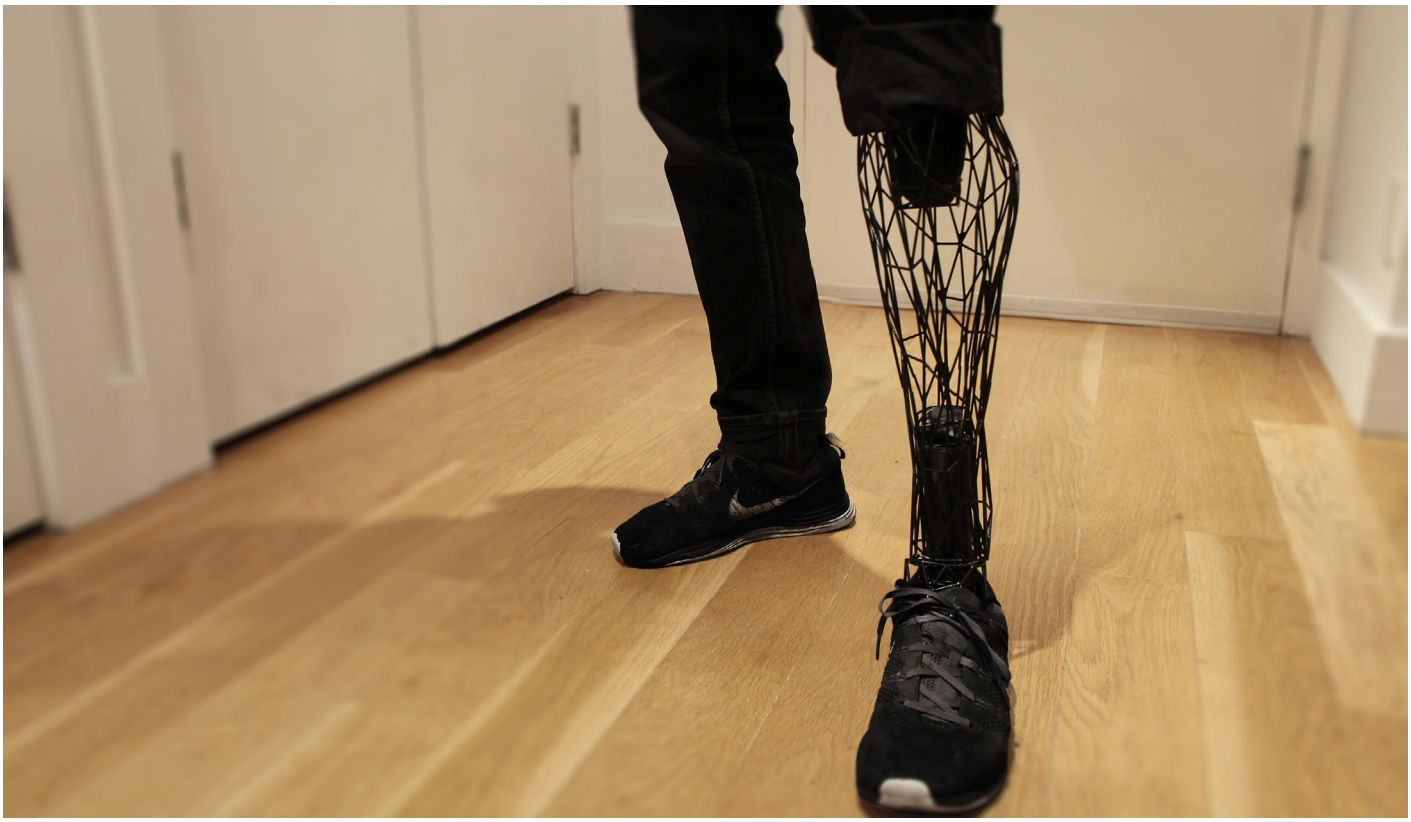
Speedier production cycles, low-volume capacity, and design freedom are driving 3D printing's adoption in motorsports. Teams from NASCAR, Formula 1, and MotoGP are printing prototypes, tools, and end-use components with the aim of creating more lightweight and aerodynamic cars. Many motorsport teams are now using 3D printing in some capacity. Stratasys recently signed a partnership with NASCAR [27] and has also worked extensively with F1 team McLaren, while composite 3D printing company Roboze supported Ducati throughout the 2022 MotoGP season.[28]

4. Healthcare

Point-of-care 3D printing in healthcare settings will transform the industry, providing more customization, efficiency, and better patient outcomes. Bioprinting is another avenue that is poised to disrupt healthcare. Bioprinting human cells in hydrogel will help tissue engineering evolve, particularly in regenerative medicine and drug development testing. While bioprinting is still very much in R&D, there is notable interest from pharmaceutical companies, who could benefit from accelerated drug testing.[29]

5. Aerospace

3D printing is linked to the aerospace industry in many ways. It is used in space to produce spare parts, in the production of satellites, to explore the possibility of printing lunar and Martian habitats and to produce rocket engines. In the case of the latter, AM is helping space launch startups, such as Relativity, to accelerate rocket production thanks to part consolidation and optimized design. Relativity's first fully 3D printed rocket, the Terran 1, is set to have its first launch in 2023.[30]



Exo Prosthetic Leg, image via William Root

Future of 3D printing

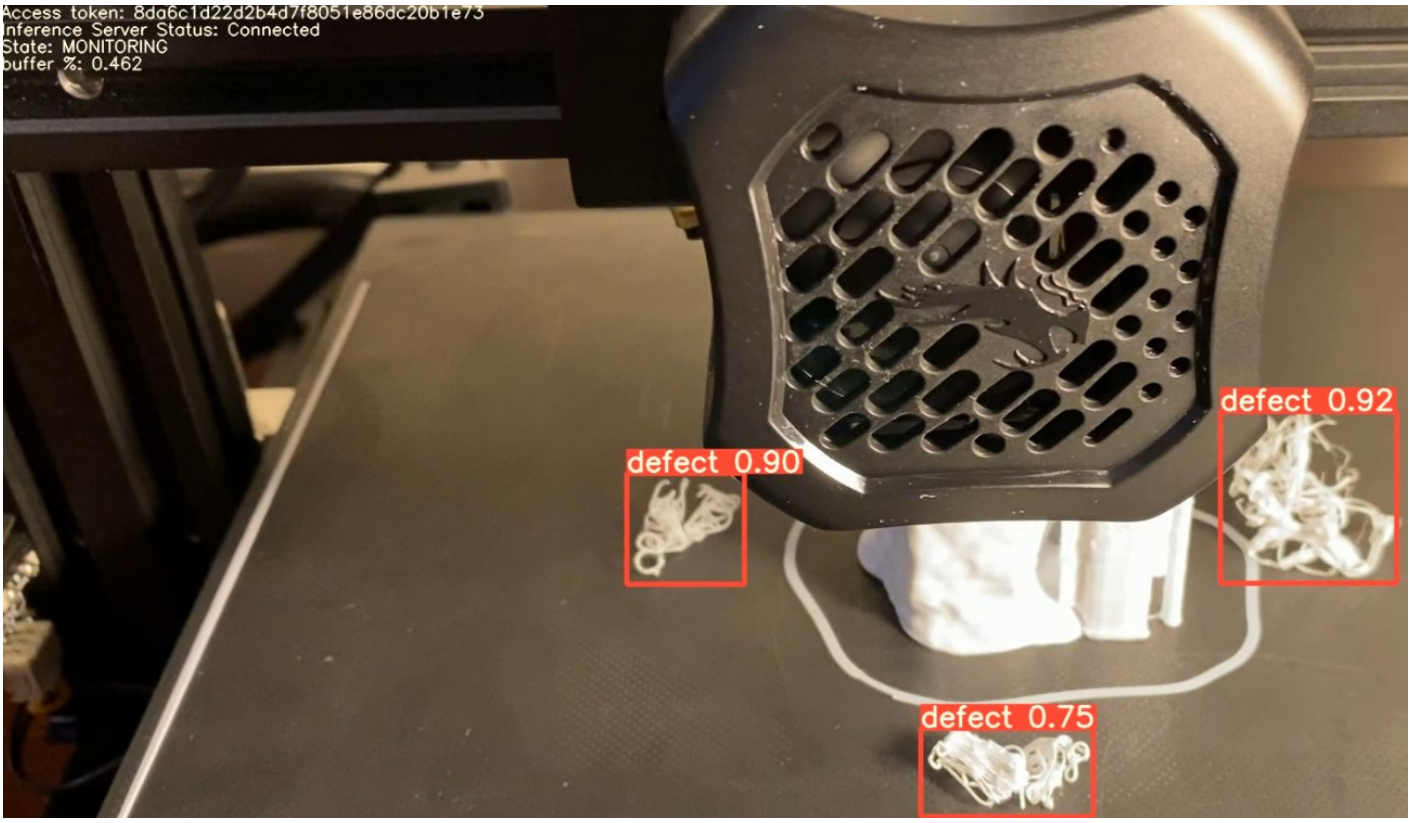
The future of 3D printing is unfolding layer by layer, much like the objects it produces. In this section, we explore the impact of artificial intelligence (AI) and smart materials on the additive manufacturing industry. To get insights into how these advanced technologies are simplifying design and production workflows, improving efficiency, and enabling the creation of adaptive products, we reached out to experts in the industry. Here are their insights on where the industry's heading.

AI-assisted 3D printing

Additive Manufacturing (AM) and AI are revolutionizing their respective fields. 3D printing has transformed manufacturing and design, while AI tools like ChatGPT, MidJourney, and Stable Difusion are changing the media landscape by generating art, articles, and stories with simple text input. The potential for innovation is limitless when 3D printing and AI converge.

Quality control
Even small defects in components can lead to catastrophic consequences in the aerospace industry. The answer is AI-enabled 3D printers, which can detect errors and correct them before they occur.

According to Jacob Wilson, Regional Manager at Bcn3d.com, "In-print monitoring has huge potential for AI integration. We're already seeing things like "Spaghetti Detection" [utilizing computer vision and ML to detect print failures] becoming increasingly popular among desktop FFF (Fused Filament Fabrication) systems."



Machine learning model for detecting defects, image via Printpal

Generative design
The democratization of manufacturing capabilities has been made possible by the widespread accessibility of consumer 3D printers and distributed manufacturing platforms such as Hubs. Nevertheless, the design process still requires a working knowledge of both CAD and slicer software, which can be complex and challenging to learn.

James Bricknell, CNET's Senior Editor, envisions AI tools breaking down the barriers to entry in 3D printing. He says, "The significant AI advancement will be 3D model generation using technologies like ChatGPT. I believe that in the coming years, we'll witness programs enabling the creation of intricate geometries simply through voice commands."

Print optimization
Achieving the right print efficiency and quality demands meticulous fine-tuning of a variety of parameters, such as layer height, infill density, path planning, and support structures. Mark Lamkin, co-founder of FYR Medical, thinks AI can ace this process. He says, "This could be something simple, such as improving layer fidelity, or more complex, like exploring novel combinations of manufacturing methods. Humans are very good at recognizing patterns, but we are slow compared to the speed of a computer."

Medical industry
3D printing has already proved its value in healthcare with customized prosthetics and medical implants. However, the existing methods can be both time-consuming and resource-intensive.

Robin Brockötter, Hubs' resident 3D printing expert, believes AI-assisted automation can speed things up. He states, "Specialized AI tools are set to reduce the complexity of the design process, making it easier for doctors and other healthcare professionals to be more involved in the undertaking."

Looking at the significant transformations that AI has brought about in various fields like art, literature, and software development, it's reasonable to assume it can also accelerate the developments in 3D printing technology. In addition to making AM faster and more efficient, AI will hopefully make it more accessible and user-friendly, to the point where it's as easy to use as your everyday office inkjet printer. For further insights, head over to this page to access the full article.

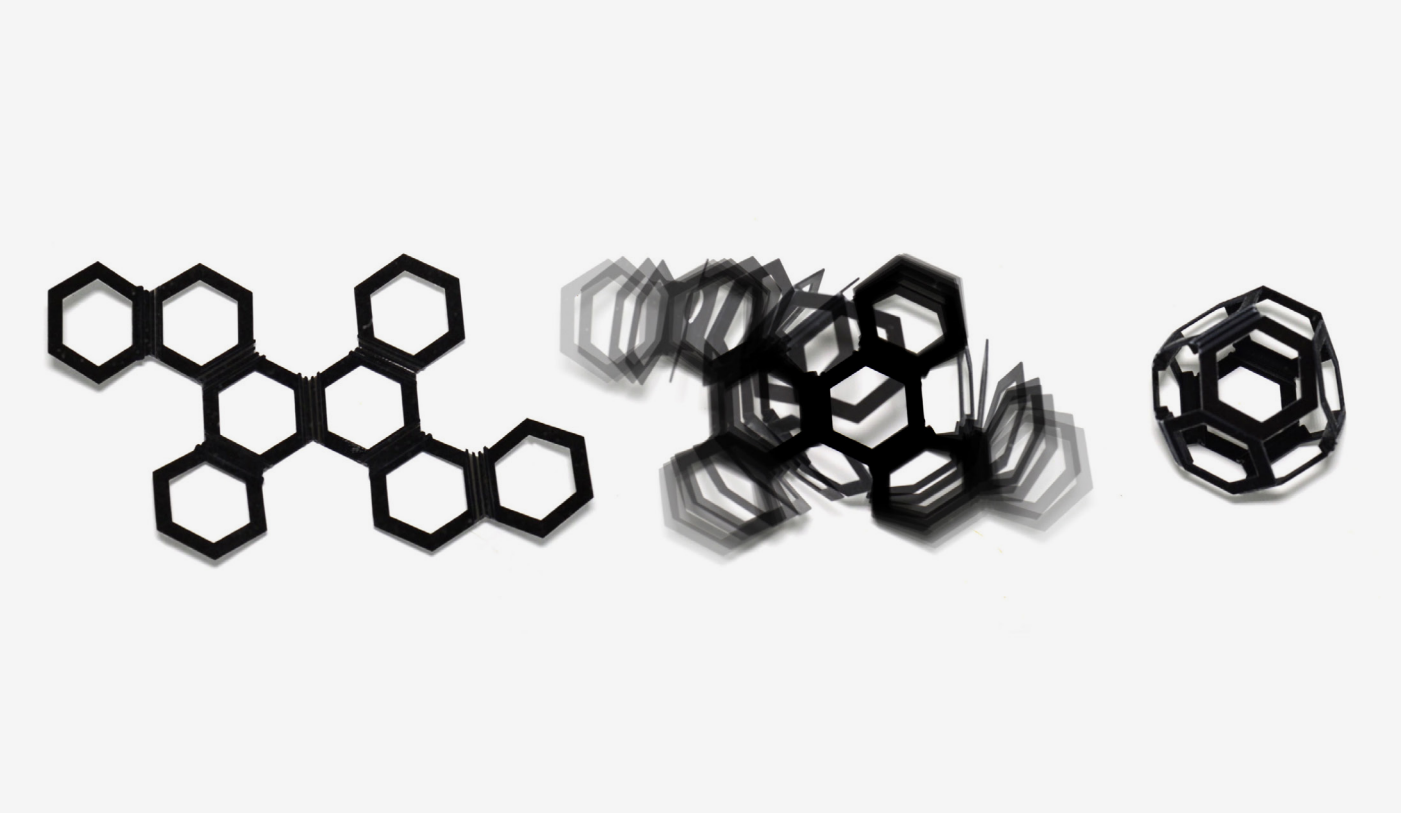
Shape-morphing systems (4D printing)

Shape-morphing systems, also known as 4D printing, add the dimension of time to 3D printing. By using responsive materials that react to external elements like heat, light, moisture, electric current, or pressure, 4D printed objects can change shape or properties. Imagine a smart textile that adjusts its breathability based on humidity or a plumbing system that expands or contracts in response to temperature fluctuations. While 4D printing is still in its infancy, it's easy to envision the huge impact it could have on various sectors.

Healthcare
Traditional implants often face limitations due to their inflexible structures. However, 4D printing could change that, allowing implants to adapt to a patient's body over time. Robert Jones, a manufacturing engineer at Nissha Medical Technologies, believes 4D printing's benefits will extend beyond implants, saying, "This technology can be used for controlling the release of a drug in the body with extreme precision."

Researchers are already creating 4D printed hydrogels for stimuli-responsive, targeted drug delivery. These hydrogels can detect changes in a patient's vitals, such as body temperature, pH levels, blood pressure, or enzyme presence, and release medication accordingly. For heart patients requiring timely access to medicine, this technology could be a lifesaver.

Aerospace
Shape-morphing components can enable aircraft to adapt to various flight conditions, reduce air drag, and enhance performance and fuel efficiency. As highlighted by Concordia University research, 4D printed drone wings, which can bend up to 20 degrees in response to stimuli, can significantly improve efficiency.[31] Beyond that, 4D printed materials can help develop lightweight, flexible structures for satellites and spacecraft, ultimately lowering the costs and complexity associated with space missions.



4D printed self-folding protein, image via Self-Assembly Lab

Adrian Nordtomme, Director of APAPTA LTD, claims that 4D printing's benefits will impact other transportation industries as well. "I believe 4D printing could be particularly intriguing in applications where an electric current is applied to the object, instead of heat or light," says Nordtomme. "This is especially relevant for the automotive, aerospace, and maritime industries, where there's a keen interest in manipulating structures for aerodynamic purposes."

Furniture

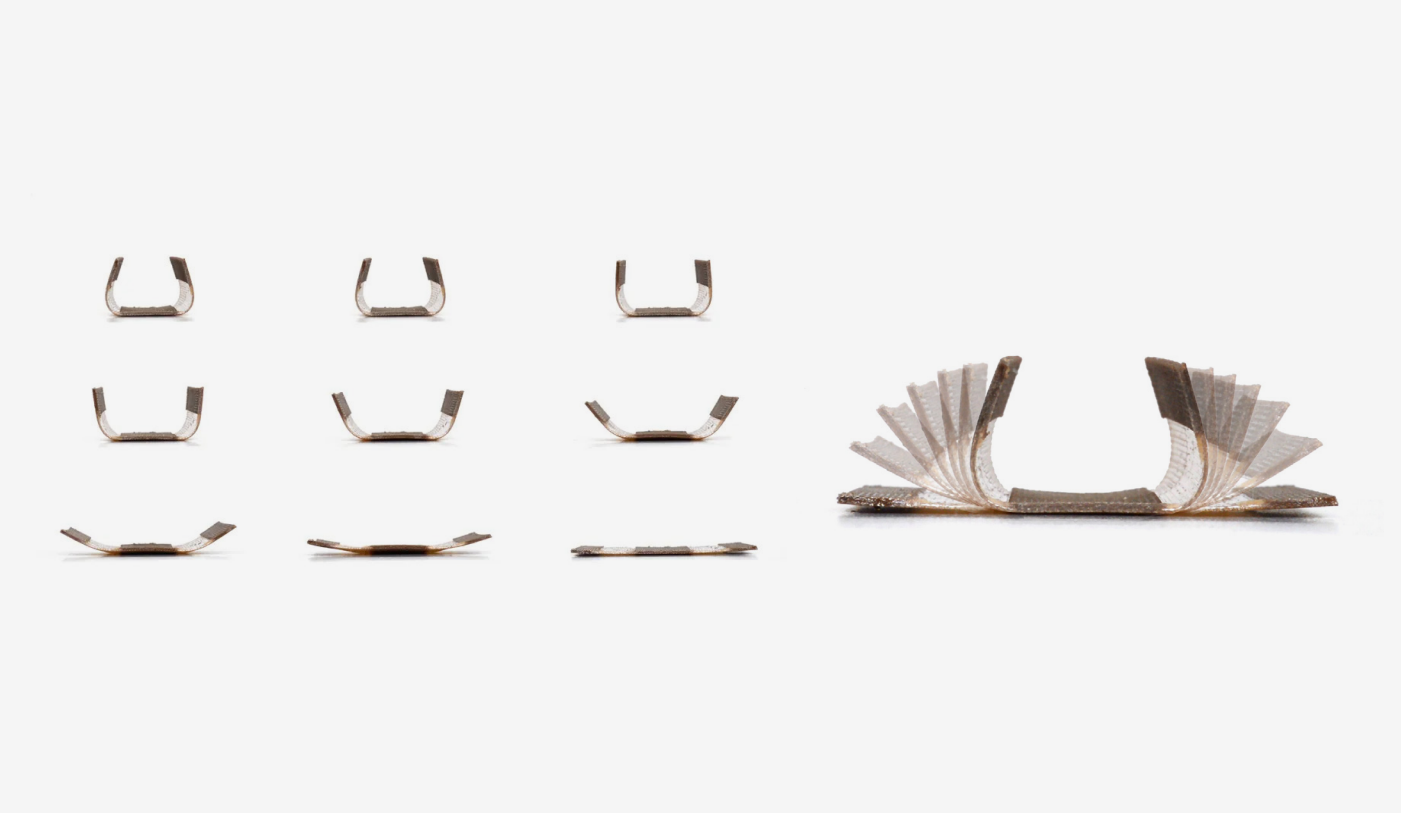
4D printing technology introduces the possibility of self-assembling furniture. In future, consumers can simply watch as their new piece of furniture takes shape, rather than spending hours following instructions and fumbling with tools. This streamlined assembly process not only saves time and effort but also makes household goods more accessible.

Francesco Rivalta, Mechanical Engineer at Hubs, thinks shape-morphing systems could revolutionize the furniture industry. "This could be the next big thing after the concept of flat-pack furniture. Imagine assembling a chair by using nothing but heat from a hair dryer."

Packaging

Using 4D printing tech, it is possible to develop packaging capable of protecting the contents from external elements such as rain, extreme cold, or heat. Additionally, this technology can automate the packaging process by enabling it to adapt to external factors.

Drawing from his experience in manufacturing at Nissha Medical Technologies, Jones explains, "It could be possible to make a type of packaging material that is stored in flat sheets, but when a product is placed on it and exposed to either light, heat, or some other stimuli, it would self-wrap and reduce the amount of labor, cost, and time spent packaging goods that may not fit easily into the standard box."



3D printed wood robots respond to external cues and change shape, image via Self-Assembly Lab

Apparel
Shape-morphing systems enable designers to create adaptive clothing and accessories that respond to both environmental factors and wearer preferences. Brands like Adidas are currently developing 4D printed shoes that adapt to users' foot shape and movement patterns, providing superior fit, cushioning, insulation, and breathability, giving athletes a competitive edge.

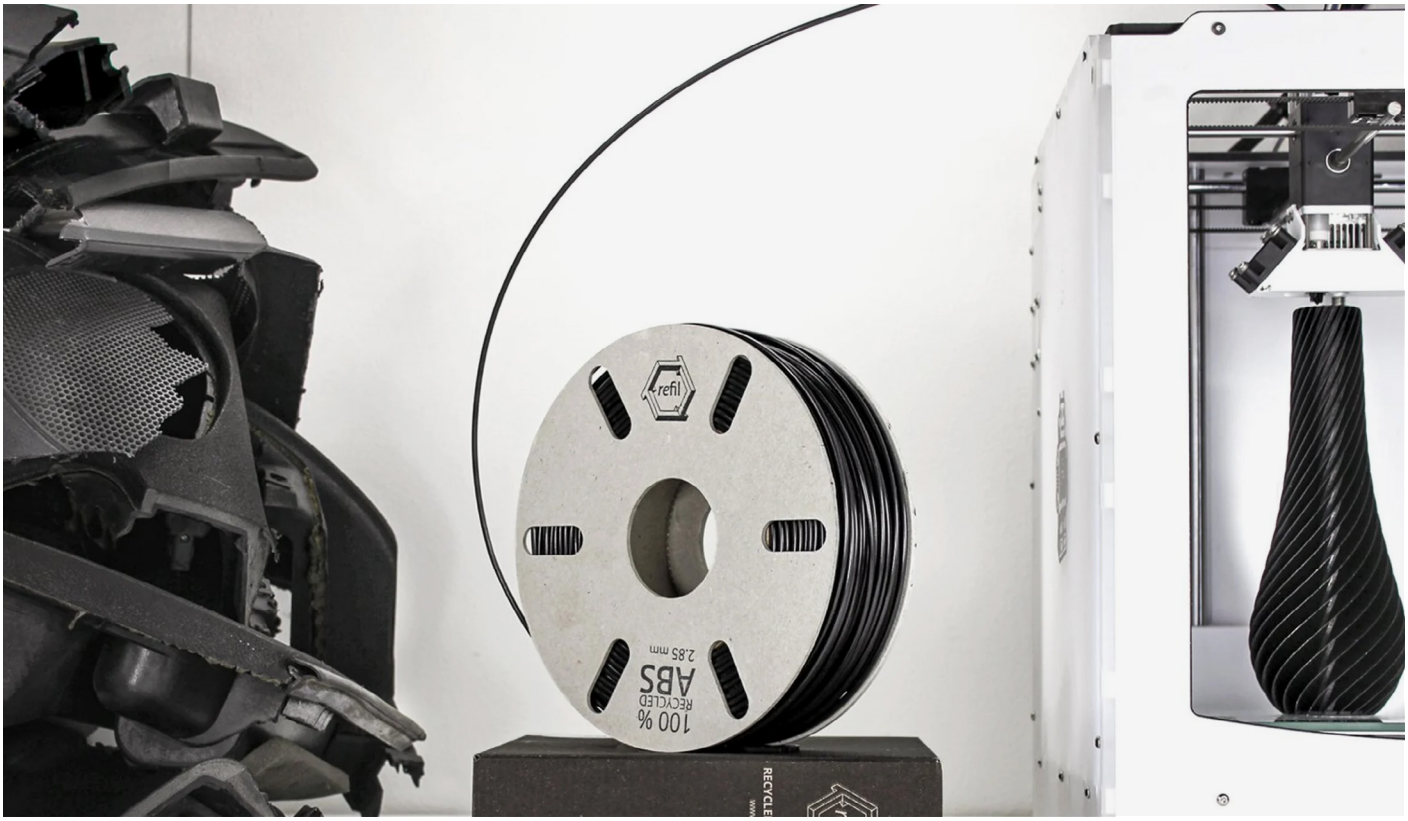
Resident 3D printing expert at Hubs, Robin Brockötter, highlights how 4D printed textiles will push the boundaries of design and functionality in the fashion industry. He explains, "Imagine a coat that adapts to the cold by becoming thicker or hiking gear that increases its breathability when exposed to sweat."

The research surrounding shape-morphing systems is spearheaded by the MIT Self-Assembly Lab, in collaboration with Stratasys and Autodesk. In recent years, numerous breakthroughs have been made in developing self-assembling and shape-shifting materials, with a wide range of possible applications. The current innovations are just the tip of the iceberg. As technology matures, even more possibilities will unfold.

Programmable textiles, image via Self-Assembly Lab

Green by design

Additive manufacturing and sustainability



Recycled plastic in filament form, image via Refil

As we chart the path towards a sustainable future, we must consider the environmental impact of 3D printing technology. While the technology could always be more optimized for sustainability, particularly in terms of energy consumption, there are a number of reasons it is continually linked with green initiatives. Here are six of them:

1. Less waste
As an additive process, 3D printing generates less material waste than subtractive manufacturing processes, like CNC machining. For powder-based 3D printing technologies, it is also possible to reuse and recycle unsintered powder for future builds. AI-powered software tools are also helping to reduce additive waste by minimizing the risk of failed prints and optimizing CAD designs for the printing process.[32]

2. Local production
The ecological impact of manufacturing extends beyond the process itself. Transport emissions are also an important factor. As a digital fabrication method, 3D printing can produce parts locally, eliminating the need for complex logistics and transport. Distributed manufacturing networks such as Hubs can facilitate local 3D printing, by providing access to qualified manufacturers all over the world.

3. Recycling
It is possible to use recycled materials for more and more 3D printing applications. There are commercial filaments made from recycled PLA, PETG, HIPS, ABS, and more. There have also been a number of creative recycling projects for 3D printing.

Italian startup Krill Design has successfully 3D printed decorative objects made from materials derived from oranges, lemons, and coffee scraps.[33] Forust, a startup acquired by Desktop Metal, has developed a binder 3D printing technology that uses sawdust as its base material.[34]

4. Optimized parts
3D printing is giving industries, particularly aerospace and automotive, the ability to achieve greater fuel efficiency thanks to intelligent part design. By lightweighting an increasing number of components, aircraft and vehicles can become more efficient and consume less fuel. Reducing an aircraft's weight by 20% can lead to 10% better fuel efficiency.[35]

5. Extending end-of-life
3D printing's ability to produce replacement parts can help extend the life of products, such as appliances, machines, or vehicles. People can 3D print spare parts at home or businesses can print them on demand, leveraging digital inventories or, for obsolete components, reverse-engineer parts. For example, many vintage vehicles have been brought back to functioning status with the help of 3D printed replacement parts.[36]

6. Circular economy
In a circular economy, waste is eliminated by finding ways to reduce material consumption and transform products into new materials. Support-free 3D printing is a key way to reduce material consumption, as is a made-to-order production ethos. There are also efforts to keep 3D printed products from landfill. For example, HP and Ford have partnered to recycle printed dental aligner molds and use the material for injection-molded fuel-line clips.[37]

The shape of things to come

3D printing has come a long way from its beginnings as sci-fi star-gazing. The technology has matured over years of innovation and progress, but it is still only on the precipice of what may one day be achieved.

Additive manufacturing has already revolutionized numerous sectors, including aerospace, healthcare, fashion, and food. As highlighted in our report, there has been a significant increase in the number of businesses producing 10 or more parts during their production runs, with the figure rising from 49% in 2021 to 76.24% in 2022. Our latest survey revealed that the primary reasons for choosing 3D printing over other manufacturing techniques are its fast lead times, ability to produce complex geometries and easy access to the technology.

At present, 20.72% of the survey participants utilize 3D printing for the production of end-use parts. However, as the technology continues to evolve towards improved efficiency, speed and accessibility, we expect a steady growth in the adoption of 3D printing as a full-fledged manufacturing method.

The tale of 3D printing is characterized by ongoing evolution. Moving forward, we can expect new layers of this agile technology that will reshape our world and the way we interact with it.

"3D printing is poised for growth as refinements in technology and reduced costs continue to make it an increasingly attractive alternative to injection molding for a wide range of applications. Its potential to mass-produce bespoke products will appeal to several industries. Looking forward, emerging innovations such as AI-assisted 3D printing and shape-morphing systems are set to unlock new possibilities."

– Alex Cappy, CEO of Hubs

How we created this report

To create this report, we collected information from three primary sources:

- A survey sent to our global engineering community
- A deep dive into 3D printing news and related media
- A side-by-side analysis of reports from well-respected analysts and consultants

We've taken insights from a survey featuring hundreds of industry innovators, a thorough review of news and media, and market research to develop a complete understanding of where the 3D printing market stands today and where it's heading.

Since our goal was to provide perspectives of those directly involved, the survey encompasses insights from engineers, designers, manufacturers, and other major players in the industry. The data collected in 2022 and 2023 paints a detailed picture of the driving forces and economic factors that are molding the future of 3D printing technologies and their applications.

Further reading

Gain more insights and practical tips within the manufacturing space

3D printing: The complete guide

Read online guide

CNC machining: The complete guide

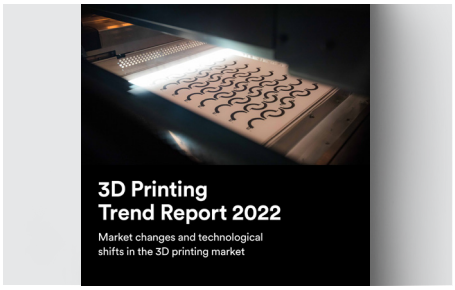
Read online guide

How to master 3D printing

Watch video series

Supply chain resilience
in manufacturing report

Read report



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About this report

Hubs
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About Hubs
Hubs is an online manufacturing platform that provides engineers with on-demand access to a global network of manufacturing partners. Users can easily upload their design, instantly receive a quote, and start production at the click of a button.

Founded in Amsterdam in 2013, Hubs was acquired by Protolabs in January 2021. To date, Hubs has produced more than 10 million parts, using various manufacturing technologies, including CNC machining, 3D printing, injection molding and sheet metal fabrication.

About Protolabs
Protolabs is the fastest and most comprehensive digital manufacturing service in the world. Its digital factories produce low-volume parts in days while its digital network of manufacturing partners powered by Hubs unlocks advanced capabilities and volume pricing at higher quantities. The result? One manufacturing source–from prototyping to production–for product developers, engineers, and supply chain teams across the globe. See what's next at protolabs.com.

For report enquiries, please contact press@hubs.com.

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