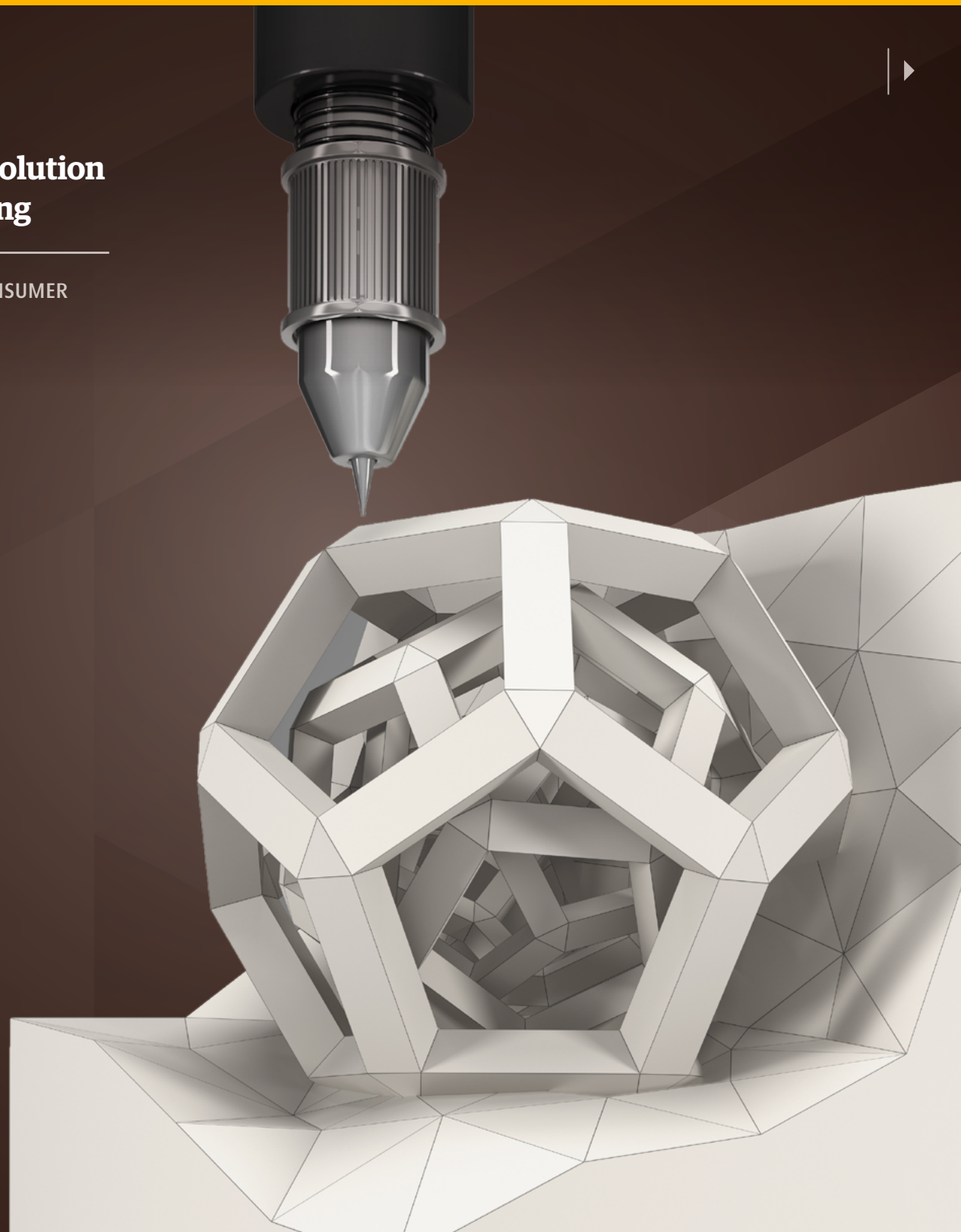
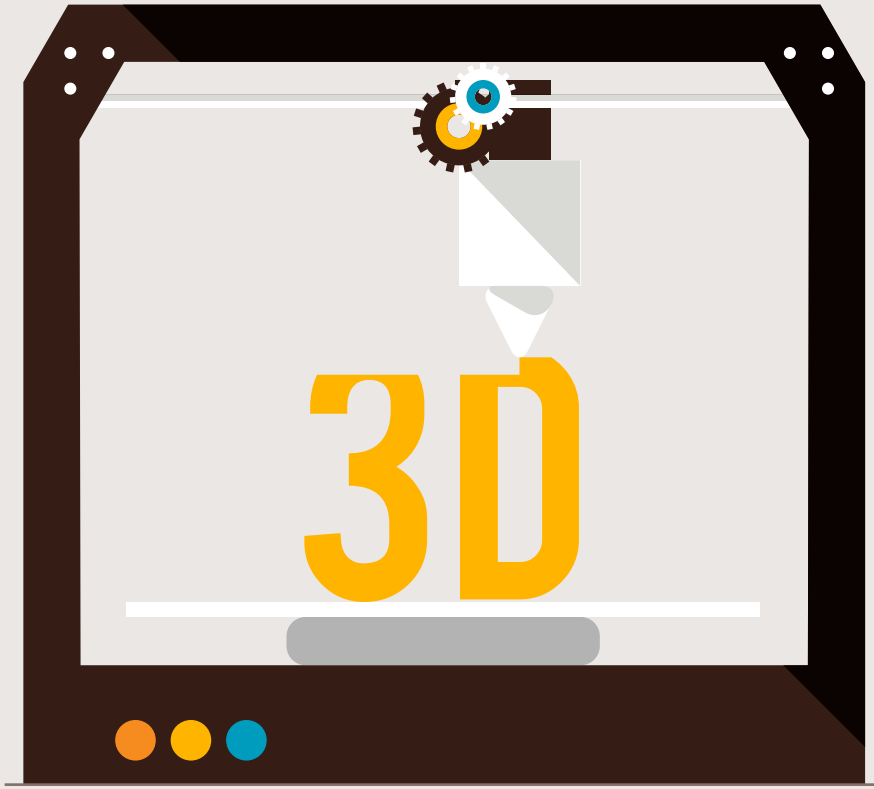
3D Printing: The Next Revolution in Industrial Manufacturing

NEW RESEARCH FROM UPS AND THE CONSUMER TECHNOLOGY ASSOCIATION (CTA)



INTRODUCTION



3D printing: An overnight success?

The technology for 3D printing has roots that go back decades. The minds behind it were visionary. But for many years, 3D printing appeared – at least in the mainstream view – to be more of a novelty than a practical tool to advance commercial manufacturing. 3D printers created one-off trinkets, souvenirs and not much else. And business leaders often were skeptical that 3D printing would ever advance enough to be an integral part of manufacturing.

Nevertheless, we are now seeing that 3D printing has reached an inflection point as lower costs and technological advances have put it within reach of more people. That's the most common use because it allows for a more agile design process and rapid product iterations. Some of the more progressive users are exploring larger-scale parts production for existing products. Meanwhile, we at UPS are taking a closer look at 3D printing as a complement to our supply chain and logistics business. We've long recognized the disruptive potential of 3D printing, and we intend to help the customer supply chain stay ahead of the curve.

UPS recently partnered with the Consumer Technology Association (CTA) to conduct in-depth interviews with U.S. companies that are early or recent adopters of 3D printing. We wanted to learn more about the factors that influence the adoption of 3D printing. This study also compiles published research and forecasts from thought leaders and analysts.

Our conclusion: 3D printing presents compelling business opportunities. Companies that wait too long to explore the potential could be missing out.

UPS is proud to present this study, which offers valuable insights into the current and future trends for industrial 3D printing.

Derrick Johnson
Vice President of Marketing at UPS

MARKET COMPOSITION

3D printing: A $7.3 billion market

Researchers estimate that the 3D printing market will reach $7.3 billion in 2016. The primary market – including 3D printing systems, materials, supplies and service – has grown at least 30% each year from 2012 to 2014. The rest of the growth comes from the secondary market, including tooling, molding and castings.

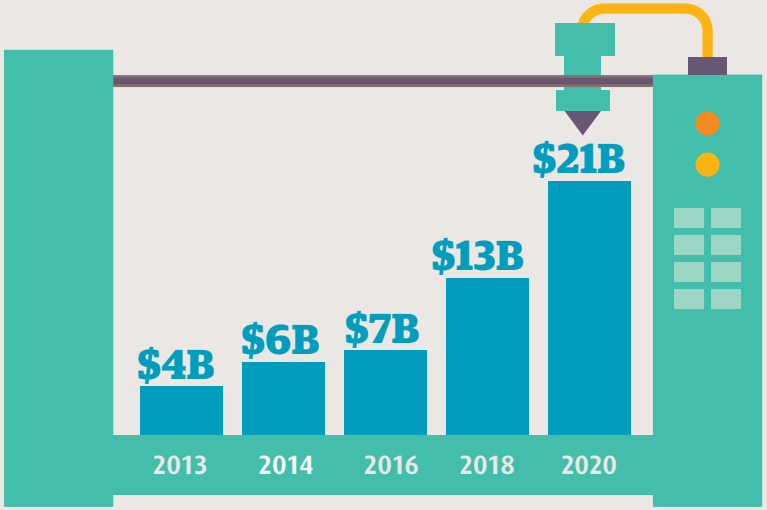
Western countries (North America and Europe) account for more than two-thirds (68%) of the 3D printing market revenue and Asia Pacific accounts for 27%.

The consumer electronics and automotive industries each contribute 20% of the total 3D printing revenue. These early-adopter industries use the technology primarily during the prototyping stage of production. For example, smartphone manufacturers are slowly using 3D printing for more than just prototyping—some component parts are now manufactured with 3D methods.

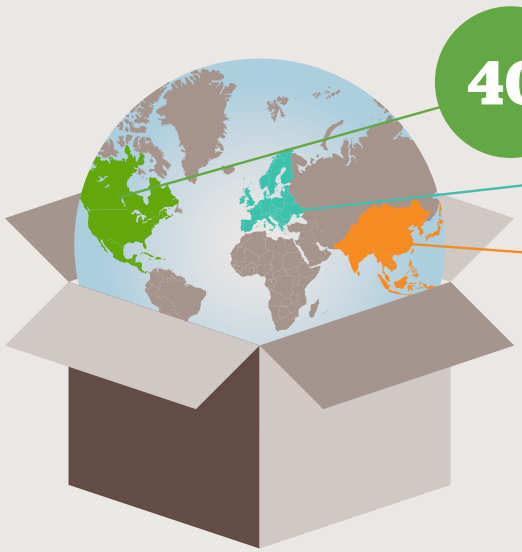
The medical device industry (15%) is the third largest 3D printing market and uses 3D printing for mass customized finished goods such as hearing aids.

Interesting fact: 98% of hearing aids worldwide are manufactured using 3D printing.

3D Printing is a Multi-Billion Dollar Market and Growing



3D Printing Market Revenue by Geography



40% North America

28% Europe

27% Asia/Pacific

The U.S. hearing aid industry converted to ~100% 3D printing in less than 500 days.

SOURCE: "Wohlers Report 2015: 3D Printing and Additive Manufacturing State of the Industry Annual Worldwide Progress Report", Wohlers Associates, 2015.

MARKET COMPOSITION

Manufacturing, a market ripe for disruption

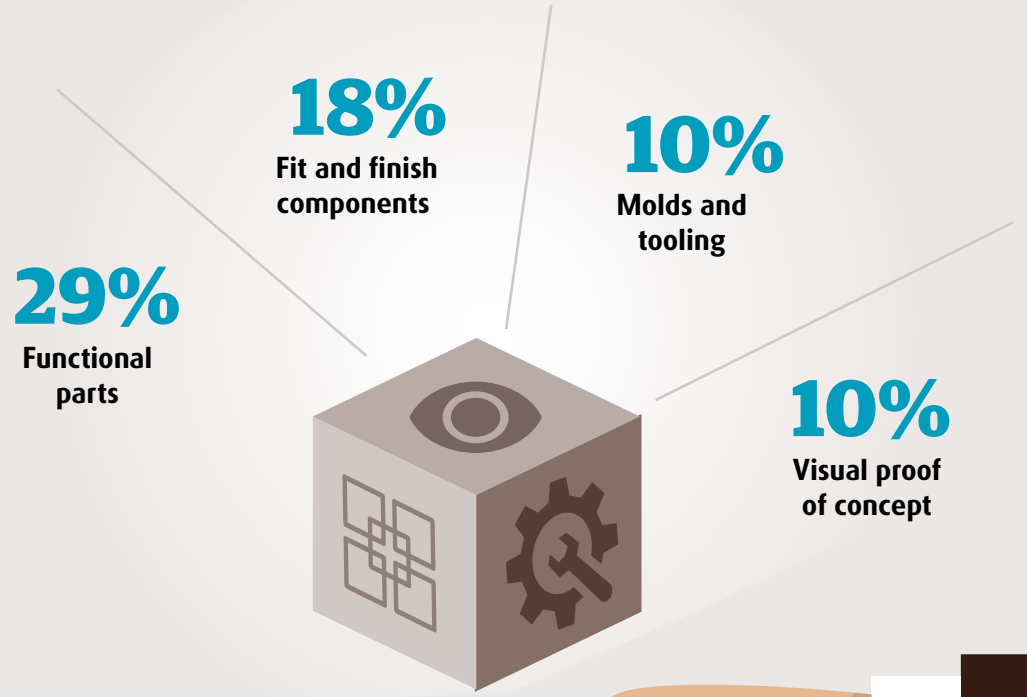
Despite significant growth, there is a wealth of untapped potential in 3D printing. In fact, 3D printing represents only 0.04% of the global manufacturing market, with prototyping as the leading use today. Wohler's and Associates believes 3D printing will eventually capture 5% of the global manufacturing capacity, which would make 3D printing a $640 billion industry.

Much of the opportunity lies in parts production – the fastest-growing 3D printing application. The use of 3D printing for parts production grew from virtually zero in 2003 to 43% ($1.8B) of global 3D-printed product and service revenue in 2014.

3D-printed parts are currently being used most for functional parts (29%), prototypes (18%) and visual aids (10%).

This is a market ripe for disruption. Technology adopters that move beyond prototyping to use 3D printing in supporting and streamlining production can achieve new manufacturing efficiencies. Plus, there is an enormous opportunity for companies that get it right.

Top Uses for 3D-Printed Goods



In 2015, 3D-printed manufactured goods represented less than 1% of all manufactured products in the U.S.

SOURCE: "Wohlers Report 2015: 3D Printing and Additive Manufacturing State of the Industry Annual Worldwide Progress Report", Wohlers Associates, 2015.

Technology trade-offs

3D printing is not a one-size-fits-all solution. For high volume, standardized applications, traditional manufacturing is likely the answer.

When is 3D printing the answer? The top reasons for pursuing 3D printing are:

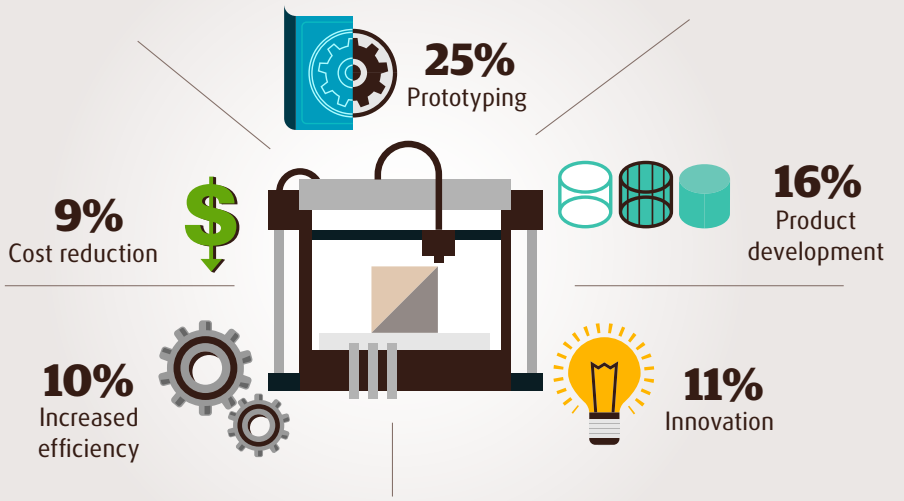
- prototyping (25%),
- product development (16%), and
- innovation (11%)

3D printing can speed development and delivery for customized products and bring increased flexibility through better inventory management and real-time production of products with variable demand. Other advantages include manufacturing advantages for small batches, cost advantages based on efficiencies for certain applications and unprecedented flexibility in new markets.

3D printing also can improve quality through lighter parts, better ergonomics and more design freedom. However, low process stability can negatively impact quality; and low reproducibility can negatively impact product durability.

It's critical to consider needs and priorities to make the decision between 3D printing and traditional manufacturing. Like everything else, there are benefits and trade-offs.

Top Reasons to Pursue 3D Printing



3D Printing vs. Traditional Manufacturing

	VOLUME	COST PER UNIT	TIME TO MARKET	COST OF COMPLEXITY
3D PRINTING	Small batch, Highly customized	High variable costs, No fixed costs	Very fast (≤ 1 day)	No higher than simple parts
TRADITIONAL	Large batch, Not customized	Low variable costs, High fixed costs	Very slow to moderately slow	Much higher than simple parts

3D printing is displacing some traditional manufacturing methods such as metal extrusion, computer-controlled machining and manual modeling techniques for prototype development manufacturing.

EXPERT PERSPECTIVES

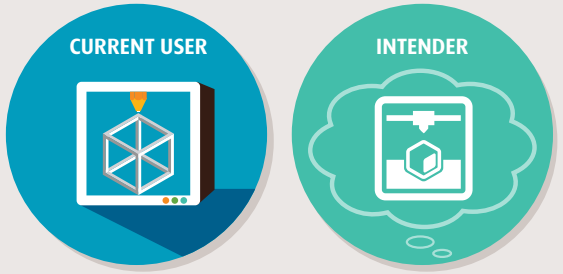
3D printing adoption

Current Users:
Two thirds of manufacturers already use 3D printing in some way, and 25% plan to adopt the technology in the future. Despite these numbers, the full potential of 3D printing is far from tapped.

Intenders:
Thirty-two percent of current users don't believe their company is fully leveraging the advantages of 3D printing while 45% of intenders would use the technology more if benefits were better understood by their company.

Influencers:
The primary influencers driving companies' 3D printing strategy are managers in R&D, engineering and or manufacturing. Demonstrating the benefits of 3D printing to these audiences is crucial for driving increased adoption.

3D Printer Intenders vs. Current Users



	CURRENT USER	INTENDER
Believe that manufacturing service providers will play an increasingly important role in the future of manufacturing	50%	61%
Have already started to rethink product design to better leverage 3DP design capabilities	40%	28%
Are now doing more 3DP in-house that used to be outsourced in the past	40%	7%
Do not believe company is fully leveraging the advantages of 3DP	32%	49%
Would use 3DP more if company better understood the benefits	25%	45%

SOURCE: "Trend Forecast: 3D Printing's Imminent Impact on Manufacturing", Stratasys Direct Manufacturing, 2015, https://www.stratasysdirect.com/content/pdfs/sys_trend-forecast_v10.pdf.

EXPERT PERSPECTIVES

Supply chain impacts

3D printing has the potential to shake up supply chains by positively impacting parts manufacturing, inventory costs and lead times.

For example, 3D printing can help companies meet demand in real time in situations when long lead times are a problem. It also can help lower inventory costs by enabling companies to maintain a virtual inventory and print parts as they need them.

3D printing can be used in centralized* and decentralized** networks; however, research has shown that using 3D printing in decentralized networks has a measurable impact on the supply chain.

3D Printing Tackles Supply Chain Challenges

*Centralized networks: Manufacturing at a single location or through a chain of single locations, focused on production efficiency.

**Decentralized networks: Production is spread out and closer to the consumer.

INDUSTRY CASE STUDIES

Consumer electronics

Present Applications
3D printing has generated positive results for the consumer electronics industry through prototype development, new product and concept designs, and parts prototyping.

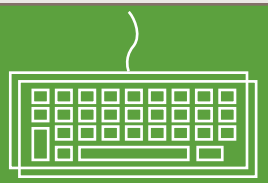
For example, a large consumer electronics company reduced design validation times from one week to one day, significantly improved fit and finish, and created better products through 3D printing. A large computer accessories company saw a return on its initial investment in just eight months of 3D printing use. A small consumer audio company experienced improved processes and workflow by using 3D printing for customized assembly components.

Future Applications
The next big 3D printing opportunity for the consumer electronics industry is in smartphones, which comprise an estimated 35% of total consumer electronics sales. Smartphone manufacturers are slowly moving beyond prototyping applications for 3D printing with more growth projected in the near future after advancements in materials and equipment.

"Our prototype turnaround time reduced from 3-6 months to 2-3 weeks. Time-to-market for new products reduced by 40-60%. 3D printing is viewed as an 'enabler' here for expanding into new markets. We initially used it once a week – but now it's used daily. The whole organization understands the value."

- Engineer/senior industrial designer at a consumer electronics company

Three Real-Life Examples of Consumer Electronics Companies Using 3D Printing

	 LARGE CONSUMER ELECTRONICS COMPANY	 LARGE COMPUTER ACCESSORIES COMPANY	 SMALL CONSUMER AUDIO/HEADPHONES COMPANY
LEVEL	Early adopter	Established user	Recent adopter
PROTOTYPING USES	Prototype development New product & concept design Show models	Prototyping parts Prototyping models	Customized assembly components
OTHER MANUFACTURING USES	Custom tooling Evaluating high volume production	Miscellaneous hardware Manufacturing	Not reported
OUTCOME	Reduced prototype turnaround times by at least several hundred percent Reduced design validation times from one week to one day Fit & finish improved significantly Better products created	Company saw return on initial investment in 8 months, and again in 18 months New manufacturing tool	Enabled customization Improved process & workflow

INDUSTRY CASE STUDIES

Automotive

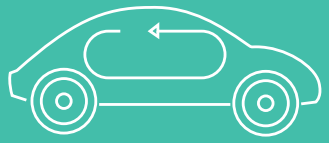
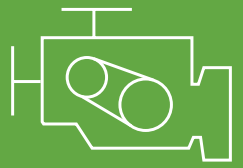
Present Applications
The automotive industry invested early once 3D printing became commercially available. Today, automotive manufacturers primarily use the technology for prototyping rather than parts manufacturing. This is likely because automotive production volumes are usually too high for 3D printing to be a viable manufacturing method for most finished parts.

3D printing users in the industry have experienced measurable benefits. A medium-sized automotive engine control company used 3D-printed sand cores for the casting of prototypes and saw prototyping time diminish from 16 weeks to one week or less.

A large automotive supplier used 3D printing for product concept prototypes, pre-production prototypes and show models. Automotive companies also experienced improved product cycle times by experimenting with 3D printing for assembly fixture, test fixtures and robotic arm tooling.

Future Applications
Making parts cheaper, lighter and faster is often a key goal of the automotive industry, indicating future opportunities for 3D printing in parts manufacturing.

Two Real-Life Examples of Automotive Companies Using 3D Printing

	 LARGE AUTOMOTIVE CLIMATE CONTROL COMPANY	 MEDIUM AUTOMOTIVE ENGINE CONTROL COMPANY
LEVEL	Early adopter	Recent adopter
PROTOTYPING USES	Product concept prototypes Pre-production prototypes Show models	3D printed sand cores for casting of prototypes Plastic prototypes for other types of components
OTHER MANUFACTURING USES	Assembly fixture Test fixtures End of arm robotic tooling Misc. parts (screws, nuts, etc.)	Evaluate new tooling for assembly process improvements
OUTCOME	Improved product cycle times	Cut prototyping time by 94% Increased revenue by a factor of 10 3DP plastics led to reduced prototype turnaround time from 2 months to 2 days

WHAT'S NEXT IN 3D PRINTING

Technology advances on the horizon

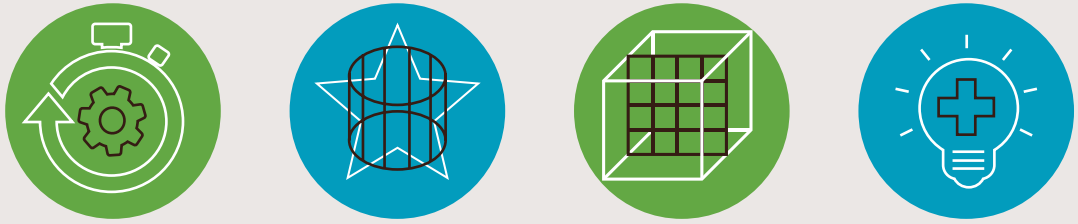
Faster Equipment Speeds
The future is bright for 3D printing applications across the supply chain. In fact, the average 3D printer production speed is expected to increase by 88% by 2023. And, as printer speed increases, volume capabilities also are likely to increase.

New and Enhanced Materials
New combinations of 3D printing materials, as well as improvements to existing materials, will not only enable unprecedented 3D printing applications, but also will help reduce prices. There will be an emphasis in metals that is likely to grow over the next three years.

Respondents to a 2015 Stratasys survey report that metal 3D printing is expected to grow faster than plastic. Eighty-four percent of respondents reported they would like to see further development with metal in the future compared to 60% with plastic.

Advanced Printing Technology and Additional Capabilities
Advancements in printing technologies and capabilities also will spur the development of new equipment and applications, like 3D-printed electronics.

Future Trends in 3D Printing



3D-Printed Materials Respondents Want to See in the Future