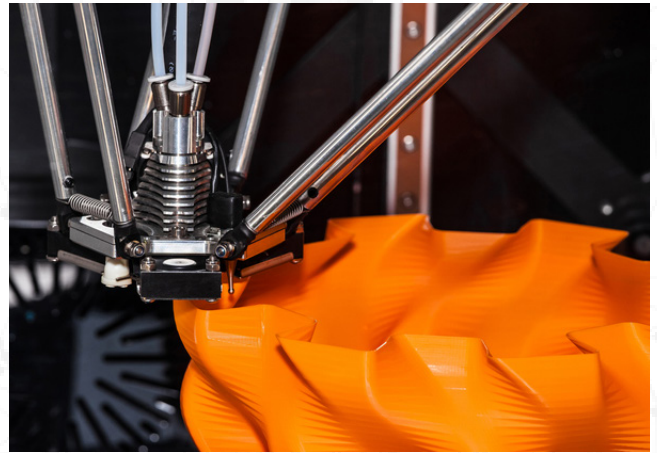


3D PRINTING: POISED FOR A PROFITABLE FUTURE

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3D printing is here, and it is transforming every industry it touches as the sector shifts from a bleeding-edge technology to a must-have competitive tool. As manufacturers large and small turn to 3D printing to reduce waste and accelerate production, and major corporations in healthcare, technology, aviation, and other major industries continue to invest heavily in 3D printing to bolster research and development, this sector has quickly become a key area of focus for investors in robotics, automation, and artificial intelligence (RAAI).



No newcomer to the manufacturing landscape, 3D printing technology (also known as ‘additive manufacturing’) has been around since the 1980s when it first appeared in consumer, traditional manufacturing, and home office/small businesses. As the technology has improved over time, 3D printers have been steadily changing the way manufacturers think about design, prototyping, and even production. But as the promise of 3D printing grew, the pace of innovation couldn’t match market expectations. Strataysys, 3D Systems, and other market leaders who couldn’t live up to overly enthusiastic earnings forecasts saw their market capitalizations decline by as much as 80%, marking a hype-and-bust cycle that lasted mainly from 2010 through 2015. While many solutions in the sector struggled to create market demand, home solutions had the greatest difficulty, failing to deliver products or price points that appealed to ordinary retail consumers. The fallout was harsh. In January 2014, Strataysys watched its stock price soar to an all-time high of \$136—and then plummet to \$25 in October 2015. 3D Systems’ shares surged nearly 200% to \$80 in 2014, then tumbled 90% when performance didn’t match expectation, dropping to an all-time low of \$7 in January 2016. (Today the stock is trading at just under \$13 a share.)

Today, that cycle has ended, thanks to rapid advancements in 3D printing technology that are making it possible for manufacturers of every size to produce more parts at a higher ROI than older, traditional manufacturing techniques. This new technology has become more accessible and cheaper than ever. Even more importantly, it is allowing for a high degree of customization that is causing the use of 3D printing for end-part production to skyrocket. The use of 3D printing for R&D is also accelerating rapidly. Merck, Johnson & Johnson, and General Motors spent more than \$29B on R&D last year, and they are investing heavily in 3D printing solutions to speed up product development and delivery across all verticals. The healthcare industry is also jumping on board. The reality of affordable, high-quality 3D printers that enable mass customization in low-volume production environments is transforming the manufacturing process for prosthetics, dental care, and consumer products. 3D printing software is also playing a major role in the upside trend. The process of 3D modeling is reliant on the use of sophisticated modeling software that is used to design each

product, specify exactly how each item is built, and then communicate that information to the 3D printer. The more sophisticated the software, the more sophisticated the design that can be created for customization. It's no surprise that software companies led acquisitions in the space in 2018. As integration with major software partners continues to evolve over the next several years, the use of 3D printing will reach new heights.

3D software solution provider Materialise is an ideal example of this collaboration in action. To create highly customized solutions for medical and consumer applications, the company has actively collaborated with emerging and established companies to develop market-changing innovations. As a result, Materialise was able to completely disrupt the hearing aid industry, spurring a total shift from traditional manufacturing to manufacturing using 3D printing—and causing the market share for 3D-printed hearing aids to jump from 20% to 100% in just two years. The company's next target is the eyewear industry. Offering an open digital platform that uses 3D scanning, parametric design automation, and 3D printing, Materialise is helping eyewear designers like HOYA to custom design every frame to meet the needs of the individual customer, including both anatomical and aesthetic preferences.

In nearly every industry where custom manufacturing is needed, 3D printing is disrupting traditional practices. Leading the way in the footwear industry is Adidas. The company is using 3D printing technology to design, prototype, and produce products that feature new materials and innovative shapes. According to James Carnes, VP of Strategy Creation at Adidas, the company has strategic plans to be the world's biggest producer of 3D-printed products as they aggressively scale productions. In 2018, the footwear industry generated \$108B, and the vast majority of companies in the space are still using traditional manufacturing techniques, creating a true greenfield opportunity for 3D printing.

All of these examples point to a rebound for companies across the 3D printing supply chain. The sector is posting improved growth rates and attractive valuations, and new industries are being added to the list of innovators that are using additive manufacturing to improve and enhance their processes, reduce production costs, and deliver a level of innovation that was not possible in the past. The downward trend seems to have finally bottomed out, creating strong potential for an upside investment opportunity. And yet, despite industry enthusiasm, market sentiment still appears somewhat weak. Funding for industrial 3D printing dipped in 2018. According to research firm CB Insights, funding and deal activity by corporate investors dropped off amid a wider slowdown in industrial 3D printing deals. While corporate investors put nearly \$1B in VC funding toward industrial 3D printing companies in the previous 5 years, funding rounds with VC investors dropped to \$130M in 2018. That's a stark contrast to the previous year, when the sector delivered 9% year-over-year growth and an 8% increase in funding. That said, M&A has by no means come to a halt. GE, which acquired former ROBO Global index member Arcam in 2016, recently acquired both Concept Laser and GeonX, demonstrating its continued enthusiasm for additive manufacturing, and GE's corporate venture arm has been active in the private space, notably as a series B investor in Desktop Metal. We believe the current attractive valuation of 3D printing solution providers will continue to draw more large, strategic players like GE to the space moving forward.

What does the current slowdown mean for investors? While the trajectory of funding and M&A over the next 12 to 18 months remains to be seen, it is clear that innovation beyond industrial 3D printing is continuing at a rapid pace—and that companies that are actively investing in 3D printing technologies and participating in strategic acquisitions are well aware of the writing on the wall: 3D printing will be foundational for the manufacturing of tomorrow. Investors who understand this potential for growth and take advantage of today's low prices on tomorrow's winners will be positioned to rise with the tide.

3D PRINTING: THE BASICS

What exactly is 3D printing? In short, 3D printing, or 'additive manufacturing,' is the process of making three-dimensional objects from a digital file using a 3D printer. Unlike 'subtractive manufacturing' in which 3D objects are built by successively cutting material away from a solid material, 3D printing uses additives—plastic, steel, titanium, gold, ceramic, and more—to build a physical object by adding micro-thin layers of an additive to form layer after layer of thinly sliced horizontal cross-sections, eventually forming the designed object.

3D printing enables the production of complex but functional shapes—everything from fine-art sculptures to complex aviation components to customized dental implants. In addition to enabling much greater complexity than traditional manufacturing, additive manufacturing virtually eliminates waste (a sharp contrast to today's high-waste manufacturing processes) to dramatically reduce the cost of nearly every end product. Today, 3D printing is playing an integral role in the Industry 4.0 revolution vision that includes IoT, machine learning, robotics, and virtual/augmented reality.

CURRENT MARKET SNAPSHOT

According to SmarTech Publishing, the additive manufacturing market is now at \$7.5B, with expected growth of 3x by 2023. In addition, the total additive manufacturing market size for software solutions will reach \$741M by 2021 and is expected to go on to achieve \$2.2B by 2025. The biggest market for this software can be found in the dental sector, followed closely by consumer products. Wohler Associates reports that current the global additive manufacturing market is worth \$11.7B¹ at a CAGR of 24.5% and poised to grow to \$27B by 2023.

The sector's success in 2018 has been attributed to two major market trends. First, large multinational corporations have made 3D printing a strategic priority.

According to a recent study², 28% of companies using 3D printing in some capacity today view applying 3D printing to product development as a top corporate priority. This is true at global chemical and materials companies as well as among developers of traditional machine tools and industrial lasers. The second key trend is the industry's increased focus on additive manufacturing applications—particularly applications that complement rather than compete with existing manufacturing processes and tools.

RETHINKING HEALTHCARE THROUGH A 3D LENS

Healthcare has been one of the biggest early adopters of 3D printing. Companies such as [3D Systems](#), [Stratasys](#), and [Materialise](#) are paving the way to industry disruption with customized solutions for endoscopic, dental, and other applications that were not possible with conventional metal fabrication technologies. Additive manufacturing for healthcare is still evolving but it is already applied in many ways and has changed the industry for the better.

Today, 3D-printed prosthetics are designed and custom-tailored for each individual user. 3D printers are helping pharmaceutical companies to create more specific drugs, enabling the rapid production of implants, and disrupting the way that doctors and surgeons plan medical procedures. 3D printed pills help patients adhere to complex medication regimes by offering a single capsule that contains multiple drugs with various release times. Researchers are using 3D printing to build human organs, using stem cells rather than polymers or metals as the production material—a process that is poised to replace traditional organ replacement. In Spain, researchers are applying 3D printing to create new skin for burn victims using biological ink that contains a combination of human plasma and material extracts taken from skin biopsies. Skin is an ideal candidate for 3D printed reconstruction as it is naturally comprised of many different layers. It may well be in the healthcare industry where 3D printing will ultimately deliver the greatest benefits of all.

¹ SmarTech Publishing's "2019 Additive Manufacturing Market Outlook and Summary of Opportunities"

² "The State of 3D Printing in 2018", Sculpteo

INDEX MEMBER SPOTLIGHT:

3D SYSTEMS

In dentistry, 3D printing already plays a key role in dental labs, and new gains are in sight as 3D technology continues to be refined and reimagined. The dental market is expected to see a Total Available Market (TAM) of \$3.7B by 2021³, providing plenty of space for 3D printing to make a marked impact. One company that is having a major impact today is [3D Systems](#). The company reaches into

every corner of the healthcare supply chain, partnering with surgeons, healthcare professionals, and medical device manufacturers to offer a broad range of precision medical solutions, including virtual reality simulators, 3D-printed anatomical models, virtual surgical planning, patient-specific guides, instrumentation, and implants, just to name a few.

So far, the dental industry has proven to be an ideal entry point for one of the most game-changing benefits to date: the ability to rethink design and accelerate prototyping in low-volume, highly customized production environments. 3D Systems is helping to transform the industry by delivering true digital dentistry in the form of 3D scanners, software, and 3D printing solutions that come together to improve patient treatment by enabling fast, efficient, and precise manufacturing of dentures, orthodontics, and implants. In the orthodontic space, 3D Systems provides the go-to technology for the largest orthodontic device producers in the world. Its award-winning NextDent 5100 printers are low-cost, high-productivity dental solutions that are expected to deliver sustainable growth over the next few years.



INDEX MEMBER SPOTLIGHT:

RENISHAW

Renishaw is the only UK business that designs and makes industrial machines that 'print' parts from metal powder. While the company supplies products and services used in applications as diverse as jet engine and wind turbine manufacturing, dentistry, and brain surgery, its healthcare products are particularly impressive.

While many 3D printing firms focus on simply building out existing designs using the efficiency of 3D printing processes, Renishaw focuses on design first, rethinking and reanalyzing every component to fully optimize the opportunity of 3D printing. This approach is helping them deliver some of the lightest, strongest, and most innovative products available on the market today, including perfectly precise dental implants and 3D-printed pieces of the human skull used in traumatic brain surgery.



³ According to 3D Systems and Smartech Research

KEY MARKET PLAYERS

3D Systems is one of the first 3D printing companies with printers, print materials, parts services, and software design tools. The company has seen a recent rebound in growth, particularly in the areas of design and manufacturing within industries such as healthcare and dental. Companies like 3D Systems are experimenting with ways to scale up 3D printing production to make it more competitive with conventional manufacturing methods in terms of ROI. New products such as its metal 3D printers should help accelerate product growth over the next several years. In addition, the company has shown improved gross profit margin in the last 12 months as they drive supply chain optimization, manufacturing efficiencies, and process improvements.

Stratasys has been in the 3D printing business since the 1980s and operates primarily in the healthcare, aviation, and auto markets. The company holds more than 600 patents in additive manufacturing globally. Its subsidiaries include MakerBot, GrabCAD, RedEye On Demand, and Solid Concepts, and it holds key 3D CAD patent technologies that help create prototypes and manufactured goods. Their customized solutions that promise a higher ROI have been earning the company traction with Airbus suppliers and Phillips. The company's strong product cycle and improved market demand should help Stratasys gain momentum in 2019.

Materialise is a leader in providing software and printing solutions. Based in Belgium, the company focuses on software and services in the 3D printing industry for the auto, aviation, and healthcare sectors and has more than 360 patents. Materialise has recently entered the consumer sector, partnering with HP to deliver customized, 3D-printed shoe insoles and offering 3D-printed eyeglasses. Materialise has also been ramping up custom medical implant design and manufacturing. With years of extensive experience in CAD and equipped with the latest 3D innovations, Materialise offers surgeons a wide range of patient-specific implants, such as cranio-maxillofacial implants, acetabular hip implants, and shoulder implants. The company's range of products and solid execution have supported double-digit sales growth.

SLM Solution Group is a German-based company that is primarily focused on industrial design and rapid manufacturing, providing its services to the automotive, aviation, tooling, medical, and education industries. SLM experienced declining growth in 2018 resulting from weakness across the automotive sector. As the company diversifies its focus to include solution-based offerings that span software, consulting, and consumer goods, combined with an expected rebound in the automotive sector, the company should see growth prospects build.

Proto Labs is a market leader in industrial-grade printing services for everything from prototyping to low-volume production. It has recently bolstered its manufacturing capacity with a new facility in Minnesota, adding to nine other manufacturing locations worldwide. With a unique, services-based business model, Proto Labs has experienced solid growth in sales and earnings.

HP is a new competitor to the 3D space, tackling mainstream manufacturing with its multi-jet fusion technology and its new MetalJet technology. Using its innovative Page Wide technology, the same technique used in inkjet systems, HP's MetalJet is able to produce 30 million drops per second across each inch of the working area which, according to HP, is up to 50 times more productive than any other 3D printing methods currently on the market and at a significantly lower cost.

Autodesk is a leader in the area of generative design, a process that mimics nature's evolutionary approach to design. The company has acquired 4 software companies in the past 5 years to expand these capabilities, and recently teamed up with GM to create the next generation of vehicle lightweighting—a method that promises to reduce vehicle mass and create parts consolidation opportunities that cannot be achieved through traditional methods. As part of a multi-year alliance, GM and Autodesk will collaborate on projects involving generative design, additive manufacturing, and materials science.

INVESTING IN THE 3D FUTURE

Investors don't need to look far to see the immense potential for 3D printing and its massive impact on manufacturing in myriad industries. Use cases for additive manufacturing are evolving at lightning speed as more engineers become familiar with the process, gain access to the newest equipment, and put their imaginations to work. Although 3D printing is unlikely to replace the majority of today's high volume manufacturing production, it offers a broad and growing range of capabilities for low-volume design and production. 3D printing workflow software, nanoscale 3D printing, wearables, and 3D-printed drugs are just a few areas that are certain to see major innovations in the next 18 to 24 months.

Looking into the future, it's easy to see a world where 3D printing has conquered an even wider array of industries, including fashion, retail, education, supply chain, life sciences, and more. For investors seeking a unique opportunity to get in on the ground floor, investing in the 3D printing industry through ROBO Global may very well be the solution you've been looking for.