



AMT TRANSFORMATIVE TECHNOLOGIES WHITE PAPERS

NEW BUSINESS MODELS EMERGE IN MANUFACTURING TECHNOLOGY MARKET

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This white paper is part of AMT's resource library on transformative technologies. There is enormous opportunity for learning, collaboration, and investment between the manufacturing and technology communities to accelerate innovative solutions and product development in the coming decade. Industry leaders agree that every part of the manufacturing value chain will be transformed by technology — R&D, the supply chain, factory operations, sales, and service. Digital connectivity among designers, managers, workers, customers, and physical industrial assets will unlock enormous value and change the manufacturing landscape.

AMT spoke to leaders and innovators throughout the manufacturing and technology ecosystems to get their perspectives on transformative technologies and where they see the key opportunities and challenges in the coming decade.

Our purpose is not to reach definitive conclusions about the future of technology in the manufacturing ecosystem since there is no single technology or type of manufacturer, but to delineate patterns that industry leaders observe and, where relevant, point out similarities and parallels with past advancements to try to shed some light on future developments.

As technology continues to transform the manufacturing ecosystem, companies will use the new technologies to create new, more flexible, and higher quality products; increase ROI; and create more efficient manufacturing processes. Those

companies who are able to successfully leverage technology advancements to create new market opportunities, or to increase company productivity, are more likely to succeed in this transformation.

AMT sees the advancement of technology as a primary avenue of exploration. We regularly partner with industry leaders to host various events, meetups, and programming. This creates networking opportunities to position the innovative groups within the manufacturing, technology, start-up, and investor communities to build alliances, networks, and support structures. Such connections will facilitate the creation of new solutions and further strengthen the manufacturing technology world.

At AMT, we look forward to the next generation of manufacturing technology and welcome hearing your opinions and experiences on this topic on our news website: **www.AMTnews.org**.

Introduction



There are many new business models emerging in the manufacturing technology (MT) ecosystem and we spoke to several AMT member companies to learn more about their paths to success. We learned that most of these innovators had a broad set of skills that combined technical know-how with proven business experience. They saw a need in the market that was not being met by current solutions and turned this into a business opportunity.

In the recent study “Age and High-Growth Entrepreneurship” published in American Economic Review: Insights, a team of economic researchers analyzed high-growth start-ups in the United States established between 2007 and 2014. They found that a founder’s average age was 42, and the average age of founders of the top 0.1% of the fastest growing firms was 45.

Although we have heard a lot about the youth of entrepreneurs like Bill Gates, Steve Jobs, and Mark Zuckerberg over the years, these are the minority. The research indicates that entrepreneurial success is not only a function of intelligence and a propensity for risk-taking, but that it depends on a variety of factors, many of which appear to improve with age. Innovative thinking benefits from experience in a variety of fields and business roles.

From this, we conclude that most innovations come from people who really understand the problems that customers in an industry face, and not from the people who just understand and develop new technologies. The members we spoke with confirmed this conclusion.



45

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3DEO : Innovative AM technology and process

Matt Sand, President, 3DEO, has started several companies over the years in widely divergent markets and considers himself an entrepreneur at heart. About six years ago, he became attracted to the potential of additive manufacturing (AM) and what he saw as its power to transform manufacturing. He partnered with Matthew Petros, CEO, 3DEO, who was then a Ph.D. researcher in metallic AM at the CRAFT laboratories at the University of Southern California (USC), and Payman Torabi, CTO, 3DEO, who was also getting his Ph.D. in AM at USC at the time. The three self-funded and launched 3DEO in 2016 with the goal of creating accurate, on-demand printing of repeatable metal parts using an innovative, patented process they developed called Intelligent Layering® technology.

Intelligent Layering® technology is ideal for serial production and can compete successfully with traditional technologies like metal injection molding and CNC machining in terms of part pricing, material properties, and quantities. In fact, part properties exceed MPIF Standard 35, the widely accepted MIM standard. 3DEO specializes in manufacturing low-to-medium volumes on demand, focusing on small, complex, stainless-steel components in

the medical, defense, aerospace, and industrial equipment markets. It also offers a variety of secondary operations including heat treating, vibratory deburring, sizing/coining, machining, and steam treating.

Sand's vision for the company has expanded since 2016, and he now believes that the potential of AM is greater than he originally anticipated. Although company growth has not been without challenges, such as scaling a new technology and hardware, his vision today has expanded to build a true “factory of the future.”

“We are currently building our first factory — a digitally integrated end-to-end production line with room for up to 50 machines and a 13,000-square-foot capacity that can produce tens of thousands of pieces a day. It will be completely data-driven, flexible, without an expensive set up, and extremely high quality — and as close to fully automated as a manufacturing facility can be. With a digital thread running throughout the factory, we will know what is happening at every point in production and be able to immediately react to any failures or defects,” said Sand.

Xometry : Innovative manufacturing marketplace model

Xometry co-founders Randy Altschuler, CEO, and Laurence Zuriff, CFO, do not hail from manufacturing backgrounds, nor do most other company executives there. However, they saw the potential of improving the sourcing process in the manufacturing industry. Launched in 2014, Xometry developed an innovative new business model for manufacturing sourcing — manufacturing as a service (MaaS) — to enable cost-effective and efficient sourcing of high-quality custom parts.

The company developed a proprietary software platform to enable customers to instantly access the manufacturing capacity of a network of over 4,000 manufacturing facilities through its internet interface and receive instant pricing, expected lead times, and manufacturability feedback. There is a very low barrier to entry — the minimum requirement is a 3D CAD model.

Xometry's carefully vetted partner network of manufacturing facilities offers comprehensive manufacturing services, including CNC machining, sheet metal fabrication, direct metal laser sintering (DMLS), selective laser sintering (SLS), fused deposition modeling (FDM), HP Multi Jet Fusion (HP MJF), digital light synthesis (Carbon DLS), stereolithography (SLA), PolyJet 3D, urethane casting,

and injection molding. And the network includes ITAR-qualified AS 9100, ISO 9001, ISO 13485, and NADCAP facilities.

“Our **business model** creates additional value for manufacturers who are **no longer subject to the limits** of their existing local suppliers, and it benefits smaller machine shops **who are no longer limited to working with customers** in only their local area.”

—Greg Paulsen, *Director of Application Engineering, Xometry*

Through its integration with artificial intelligence (AI) and neural network learning, Xometry's MaaS platform analyzes part geometry and open capacity to find a market-efficient price that benefits both customers and manufacturing partners. It also collects valuable data on product features customers are requesting and the most effective production techniques that it shares with company partners through its recommendation engine.



To date, Xometry has received \$118 million in VC investment from several companies. Even very large companies such as Bosch and Dell, BMW, and GE — with extensive and finely tuned supply chains — have found value in the company’s MaaS platform.

“Our business model creates additional value for manufacturers who are no longer subject to the limits of their existing local suppliers, and it benefits smaller machine shops who are no longer limited to working with customers in only their local area,” said Greg Paulsen, Director of Application Engineering, Xometry.

“We are using machine learning to accumulate a growing mountain of data about ‘best case’ costs and manufacturability for parts,” continued Paulsen. “This data did not exist before, and it opens up all sorts of new business models. For one, our manufacturing platforms have the capability to take advantage of underutilized manufacturing capacity globally.”

Xometry has grown rapidly since its founding and recently acquired German company Shift, which has an established manufacturing network in Europe. This will accelerate Xometry’s international expansion into 12 new countries in Europe.



PROTOLABS: Innovation in low volume manufacturing

Protolabs is a digital manufacturer of low-volume, custom, on-demand production parts and prototypes. Its manufacturing services include 3D printing, CNC machining, sheet metal fabrication, and injection molding services, and it has nine manufacturing facilities globally. Unlike Xometry, Protolabs is a manufacturer, not a middleman broker.

“Protolabs built its manufacturing model from the ground up, deciding to focus on speed and low volume simultaneously. We saw that prototype and low volume custom parts manufacturing was an underserved market due to the inefficiencies inherent in the quotation, equipment set-up, and non-recurring engineering processes required to produce custom parts, and that’s the problem we set out to solve,” said Dan Barsness, Global Vice President of Product, Protolabs.

Customers typically order short run custom parts when they need a prototype to confirm the form, fit, and function of a component or product under development; when they need an initial supply of parts to support pilot production for market testing of a product; if a product will only be released in a limited quantity; or if they need to support end-of-life production cost effectively. For Protolabs, low volume is between hundreds and tens of thousands, with the minimum part quantity being one for all services.

The company developed proprietary software and advanced manufacturing processes to automate much of the expensive skilled labor conventionally required in quoting, production engineering, and custom parts manufacturing. The platform automates many aspects of the process from design submission through manufacturability analysis and feedback, quotation, order submission, mold design, tool path generation, mold or part manufacture, and digital inspection.

Customers upload a 3D CAD file of their required part through an interactive web-based interface, and within minutes of design submission, the software analyzes the design, assesses the manufacturability of the design, and returns a firm price quotation with any recommendations for design modifications. The quoting system is highly interactive, enabling customers to change the material, finish, quantity, or shipping schedule of orders, and to instantly receive an updated quotation.

Protolabs’ business model and services create new opportunities for other manufacturers as well. It enables a manufacturer to say yes to work that does not fit into its business model, and then outsource that work to Protolabs, freeing up time to take advantage of business opportunities that are a better fit.

VELO^{3D} : Freeing AM from support structures

Benny Buller, CEO and Founder of Velo3D, metal AM market entrepreneur and leader, did not hail from a manufacturing background either. “Benny founded Velo3D because he wanted to make it easier for people to enter additive without redesigning their parts,” said Joyce Yeung, Director of Marketing, Velo3D.

Velo3D brought together innovations in software, hardware, and process control to create the industry’s first “SupportFree” manufacturing solution for 3D metal printing, enabling unlimited design innovation by reducing the need for support structures in AM. This new category within laser powder bed fusion allows customers to use AM for direct part replacement, a completely new application.

The need for support structures in AM has been a major technical issue that has needed to be considered when a part is designed, requiring the designer to either omit overhangs that might droop during the additive build or, when this is not possible, to add in support structures to buttress those features. Adding supports can also entail redesigning a part to offer access to those features so they can be removed later via machining or manual postprocessing. The impossibility of removing supports from many parts is why many existing part designs are not transferable to AM.

“We believe that printing your parts ‘as-is’ is the path with the lowest amount of friction for mass adoption of additive. When we have conversations

with some of the biggest OEMs, this is exactly what they say they want. They don’t want to redesign, they don’t want to integrate variables into their process, and they don’t want to enter that vicious cycle of prototyping that is often associated with new product development,” said Yeung.

Design for AM must follow a strict set of rules; for example, you can’t have shallow angles (anything under a 45-degree angle must have support structures with today’s processes), and you can’t have wide inner diameters. But the Velo3D process lets customers print with very shallow angles and print tall skinny parts with higher first-time yield.

To date, Velo3D has raised \$110 million from VCs and is starting a new Series D round. It has two aerospace OEMs in serial production, and one of them has 12 machines. AM industry analyst group SmarTech Analysis, which grades metal AM firms on the strength of their portfolio of patented intellectual properties, recently awarded Velo3D the top assignee position across the metal AM landscape.

Yeung works to create thought leadership for the company with the mission of creating a paradigm shift in the industry. “Using AM for direct part replacement is counterintuitive to what the industry is talking about right now. We’re perceived as going against the grain and what our competitors are telling their end users. I help educate the market about this new category of capabilities, communicating our value proposition and our innovation in AM printing,” said Yeung.



TANGIBLE SOLUTIONS : Strategic market focus a winning formula

Tangible Solutions, a contract manufacturer of 3D-printed, titanium implants, was founded in 2013 in Dayton, Ohio by Charlie Fox and Chris Collins, COO. Shortly after founding, Adam Clark joined the company as a managing partner and currently serves as CEO. The company converted from a limited liability company to a corporation in 2016.

Initially, the company offered a broad range of additive manufacturing services, design, and training seminars for a variety of industries. In 2016, Clark and Collins made a strategic decision to focus solely on becoming a contract manufacturer of 3D-printed, titanium, orthopedic implants. From that point onward, they sold off equipment and turned down work that did not contribute to their core focus. The company has expanded twice and now operates a 25,000-square-foot production facility.

The company has faced some challenges along the way. As an early example, after purchasing and installing metal-AM machines several years ago, they learned that an \$80,000 HVAC system was a requirement, not an option. Without temperature and humidity control, the equipment could not appropriately validate.

Reflecting on the challenges of growing the company, Clark said, “In the early days, going from plastics to metals and prototyping to contract manufacturing was a challenge, yet we succeeded. Now that we are established as a contract manufacturer in our field, it’s game on. We have a high level of focus on our niche

and have become experts in everything our customers must go through to achieve product clearance from the FDA, and that’s a differentiator.

“For those starting without metal-AM experience, I recommend an 18-month timeline from ordering the first machine to reliably producing quality parts. Being a heavy user, we have had a lot of obstacles, even perplexing the OEMs of 3D printers, and we have had to figure out a lot of things ourselves. There is so much to master, I strongly recommend focusing on one industry, one application, one metal-AM platform, and one material.”

“Now that we are established as a **contract manufacturer** in our field, it’s game on. We have a **high level of focus on our niche and have become experts in everything** our customers must go through to achieve product clearance from the FDA...”

—Adam Clark, CEO, Tangible Solutions

Today, Tangible Solutions is formally registered with the FDA as a nationally recognized contract manufacturer of class (I), (II), and (III) 3D-printed, titanium implants. The company has ISO 13485:2016 and ISO 9001:2016 accreditation.

The Bottom Line

There are many new business models emerging in the MT ecosystem. Company founders and executives come from a wide variety of backgrounds and not necessarily from the manufacturing ecosystem. What they have in common is the ability to see a need in the market that is not being met by existing solutions and turning this into a business opportunity.

- **3DEO.** Intelligent Layering® technology for serial production which competes successfully with traditional technologies like metal injection molding and CNC machining in terms of part pricing, material properties, and quantities.
- **Xometry.** Manufacturing as a Service (MaaS) to improve the sourcing process and enable cost-effective and efficient sourcing of high-quality, custom parts.
- **Protolabs.** Manufacturer of low-volume, custom, on-demand production parts and prototypes enabled through proprietary software and advanced manufacturing processes that automate much of the expensive skilled labor conventionally required in quoting, production engineering, and manufacturing.
- **Velo3D.** The industry's first "SupportFree" manufacturing solution for 3D metal printing, enabling unlimited design innovation by reducing the need for support structures.
- **Tangible Solutions.** Strategic move from manufacturing AM prototypes for broad customer base to exclusive focus on manufacturing class (I), (II), and (III) 3D-printed, titanium implants for the national market.

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About AMT

AMT - The Association For Manufacturing Technology (AMT) represents and promotes U.S.-based manufacturing technology and its members — those who design, build, sell, and service the evolving technology that lies at the heart of manufacturing. AMT also owns and manages the International Manufacturing Technology Show (IMTS), the premier manufacturing technology event in North America. AMT acts as the industry's voice to speed the pace of innovation, increase global competitiveness, and develop manufacturing's advanced workforce of tomorrow. AMT was founded in 1902 and is headquartered in McLean, Virginia. For more information, visit www.AMTonline.org.

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