Gain the competitive advantage.

Implement 3D printing to hasten product development, future-proof supply chains and grow your business.

stratasys

Introduction

In 2019 the global 3D printing market **surpassed $10 billion.** It's projected to double in size every three years with an annual growth rate between 10 and 27 percent. **This is no small trend.** Does your business factor into those numbers? Does it matter?

In fact, numerous companies across an array of industries are using 3D printing to transform their business, create new revenue opportunities, develop more agile supply chains and gain competitive advantage. Realizing those strategic advantages, however, takes smart investments and leadership.

The world of 3D printing, or additive manufacturing as it's sometimes called, covers a lot of ground. This white paper will help break it down for you.

We'll start by explaining how 3D printing differs from traditional manufacturing. Then we will cover six main business drivers of 3D printing. We'll apply those six business drivers to the entire product lifecycle, from development to end-of-life. Finally, we'll help you make the business case so you can get started on your additive journey. We're here to help. **Are you ready?**

Contents.

//Chapter 01

A New Way to Make Things

Until the advent of 3D printing, making things has involved three fundamental processes: removing material, joining materials, or reforming materials to a desired shape. Making objects additively, layer by layer, is an entirely new manufacturing methodology distinct from those subtractive, fabricative, or formative processes. It sounds like a small thing, but it has huge implications for how parts can be produced, and in turn, how supply chains operate, businesses sell, and manufacturers invest.

Because 3D printing uses this layer-by-layer, particle-by-particle approach to manufacturing, it is able to make complicated shapes that are unimaginable using traditional processes such as molding, machining, or casting. Unlike these traditional methods, complexity with 3D printing is also dislocated from cost, making it a highly efficient way of creating intricate shapes.

Combine this with the fact that 3D printing is entirely digital, and suddenly the traditional relationship between part cost and production volume evaporates. We now have a process that is highly suited to lower-volume production applications where traditional tooling investment would be difficult to justify.

To put it simply, with 3D printing, complexity is free, economies of scale don't exist, and things can be produced wherever there's a 3D printer, independent of traditional factories.

"

...suddenly the traditional relationship between part cost and production volume evaporates...

//Chapter 02

The Business Drivers of 3D Printing

3D printing is used across a variety of business sectors to drive innovation, support manufacturing and accelerate new products and services to market. However, as a complement to other technologies, it shouldn't be viewed as only a different way of making things. Rather, 3D printing presents compelling business benefits that drive its adoption where it makes sense. These benefits are characterized by six key drivers.

//01
Freedom of Design

Conventional manufacturing is limited by certain physical constraints, requiring design-for-manufacture-and-assembly (DFMA) considerations. However, the restraints of DFMA are substantially reduced through the additive nature of 3D printing, enabling the manufacture of highly complex geometries in a singular production process with little or no cost-penalty.

GKN Aerospace relies on the creative freedom of FDM® 3D printing to make tooling that is uneconomical or just physically impossible to produce conventionally. This reduces cost and provides greater optimization for usability and efficiency.

//02 Embedded Functionality

The digital nature of 3D printing allows for the precise positioning of multiple materials at a micron scale. This opens up the possibility of embedding new kinds of functionality into products, whether it's computer intelligence, exotic material properties, unique motion properties, and much more. This capability can eliminate manufacturing steps, reducing cycle time and cost.

John Crane, a global rotating equipment provider, significantly reduced the production cost of an impeller casing for a spin test rig with additive manufacturing. Using 3D printing instead of machining, the company was able to combine 22 pieces of the previous design into one part, reducing manufacturing costs by 98% and test costs by 65%.

Up to

98%

reduction in manufacturing costs

//03 Streamlined Supply Chains

3D printing's ability to produce parts on demand relative to traditional manufacturing processes means supply chains can be reconfigured for zero-inventory "digital stock." This point-of-use production shortens the supply chain, hastens delivery, and reduces inventory costs. When traditional supply chains are impacted by work shortages or unforeseen events, 3D printing's capabilities short-circuit these roadblocks allowing companies to continue producing.

FedEx Forward Depots provide just-in-time delivery of spare parts and electronics repairs. By producing critical spare parts and tooling in-house using 3D printing, FedEx both shortens the supply chain and lowers the logistics overhead for its Forward Depot business. This lets FedEx repair electronics faster than the original manufacturer, sometimes as soon as the next day.

75%

of global manufacturing operations will be using 3D printed components to produce end-use parts

//04 Hyper Personalization

By removing traditional economies of scale, personalization can go mass-market, opening up a huge opportunity across sectors to add value to products through personalization, when it was previously cost-prohibitive. This can be considerably important for companies such as automakers to economically justify greater personalization in their products, allowing for market distinction.

Daihatsu offers its customers the ability to personalize their cars on the Copen model. Car owners can choose from 15 different 3D printed "Effects Skins" exterior panels created by designers. Because the customer can adjust the parameters of the designs themselves, there are exponentially more styles and preferences that can be personally customized, a concept that wouldn't be economically viable without additive manufacturing.

Author: TenenGas Permission: GFDL

//05 Lower Volume Manufacturing

Unlike traditional production processes, 3D printing is entirely digital and toolless, meaning there's no capital cost difference between printing one part or a thousand. The result is that companies can disrupt the traditional economies of scale, by allowing cost-effective production of low-to-mid-volume batches.

3D printing has proven to be an effective solution to replace obsolete interior parts on railway passenger cars. Angel Trains, a UK rail industry stock provider, 3D prints parts such as armrests and grab handles on-demand. This cost-efficient production method allows Angel Trains to economically produce parts in low numbers and enable rail operators to get trains back into service faster.

//06 Lifecycle Sustainability

From minimizing manufacturing material waste to reducing fuel costs by light-weighting parts, 3D printing can reduce environmental impact while simultaneously growing the bottom line.

Airbus standardized the use of ULTEM™ 9085 thermoplastic for the production of flightworthy 3D printed parts on its A350 XWB aircraft. The high strength-to-weight ratio of this material provides an efficient alternative to traditional metal parts and a resultant lower fuel burn and operating cost over the life of the aircraft.

//Chapter 03

3D Printing Across the Product Lifecycle

3D printing impacts at least five major business functions: prototyping, tooling, manufacturing, sales and retail, maintenance and aftermarket support.

Prototyping

Prototyping is an expense, and the benefit of iterating concept models, visual aids, and functional prototypes can quickly be outweighed by the time and cost it takes to fabricate them. Yet iterations inherently lead to better product designs. Ultimately, a business must balance two opposing forces in the product development process: the need to iterate and perfect the design versus the pressure to get to market.

3D printing changes this equation because it supports two seemingly contradictory goals: enabling more iterations of prototypes while simultaneously reducing development time. Because 3D printing is toolless, a printer can produce 10 variants of a prototype in the time it takes a talented designer to create a single visual prototype using conventional techniques. It empowers designers and engineers to more closely achieve perfection through the fast iteration process, while simultaneously meeting or beating deadlines set by product managers and executives.

The beauty of today's multi-material, multi-texture, full-color 3D printing technology is that designers can now produce high-fidelity prototypes that are virtually indistinguishable from the final product. Combined with the speed at which they can be produced, it enables a significant reduction in the design process and time-to-market. That's a compelling incentive for design firms and companies in the competitive consumer products business.

Investment and Implementation

Prototyping is a secure investment for 3D printing, thanks to a successful track record and well-defined benefits to the design and engineering processes. It's also one of the easiest stages in the product lifecycle for a business to implement the technology.

Effective implementation requires thought about how the technology will affect the existing development process. Transition to a rapid prototyping approach may require investment in technologies, people skills, management and organizational change beyond the internal prototyping department.

Kinetic Vision, a product development consulting firm, produced this prototype for a consumer products packaging client. Kinetic Vision used full-color, multi-material 3D printing, capable of producing colorful graphics, legible text and complex designs in a single print operation.

Tooling

As a digitally driven, on-demand, flexible production platform, 3D printing eliminates many of the costs and limitations faced by companies looking to produce jigs, fixtures and other tooling in-house: namely, the high cost of skilled machinists and the capital tied up in machining equipment. It also reduces the risks of long supplier lead times and high fabrication prices for outsourced tool production. In an era of growing business uncertainty, 3D printing enables companies to design, print, and deploy jigs and fixtures more cost effectively, faster and in more applications than what was previously possible.

As mentioned previously, complexity is free with 3D printing. This opens up new opportunities for tool configurations that were previously cost prohibitive or limited by design-for-manufacture constraints. Existing tools can be reviewed and their designs improved to be more lightweight, multi-functional, durable and ergonomic. Multiple jigs and fixtures can be consolidated to fewer, more advanced 3D printed tools, reducing the number of individual operations and unique tools in total.

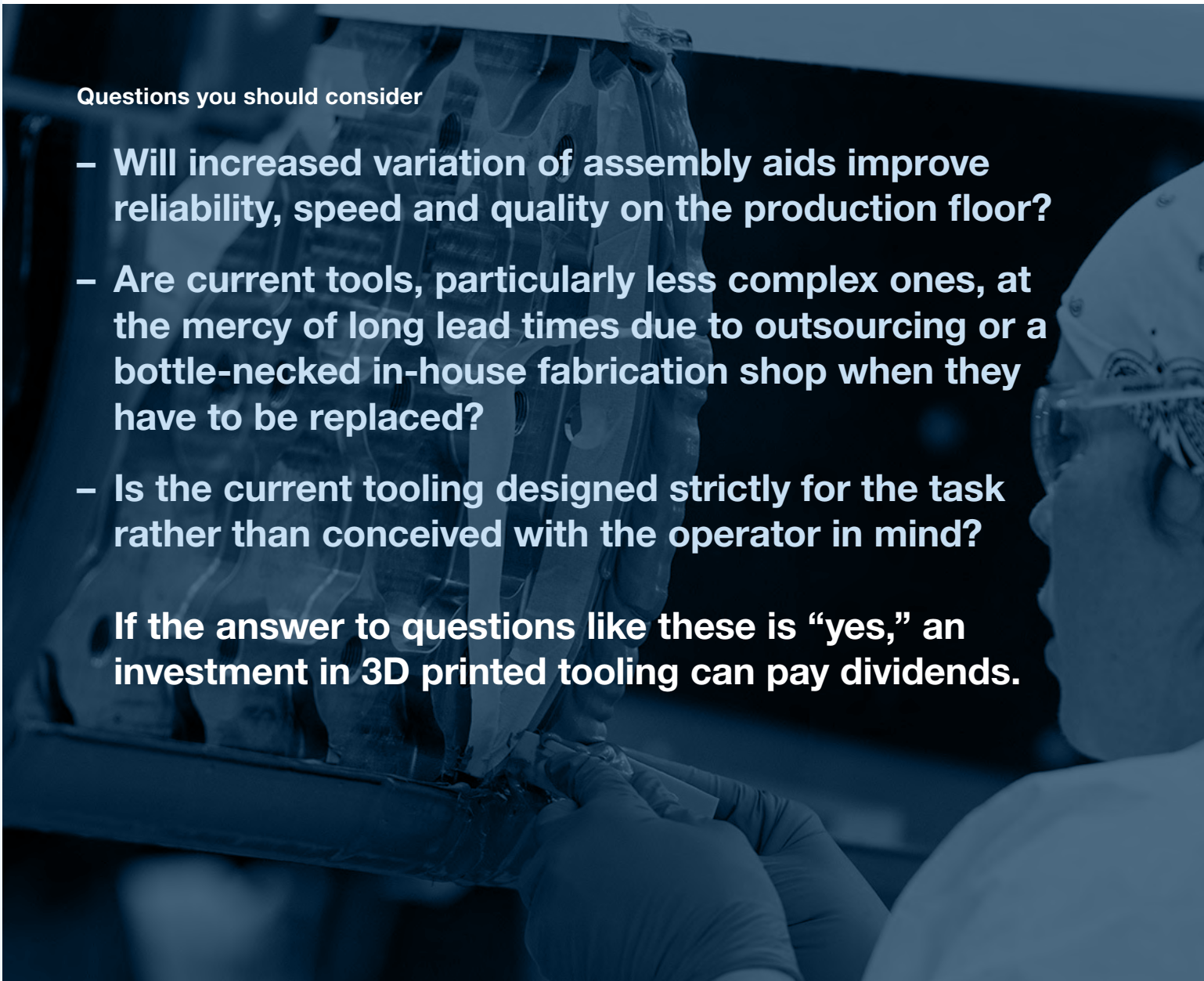
When identifying an appropriate 3D printing technology, consider whether it meets the actual requirements of the jig or fixture, and not whether it can match the often over-engineered material properties or tolerances offered by conventional machining. With this approach, you can reap savings by no longer using high-cost machining methods to produce lower-value tools.

Boom Supersonic used 3D printed flight control test rig tooling for its XB-1 supersonic jet. The printed tools resulted in a 90% cost and lead time savings over conventionally produced tooling.

Tooling

Investment and Implementation

Implementing a 3D printed tooling strategy is a good next step for any company looking to expand 3D printing outside of the prototyping department. With many lower-cost, office-friendly 3D printing technologies capable of producing jigs and fixtures, the technology barrier for getting started can be modest.



Questions you should consider

- **Will increased variation of assembly aids improve reliability, speed and quality on the production floor?**
- **Are current tools, particularly less complex ones, at the mercy of long lead times due to outsourcing or a bottle-necked in-house fabrication shop when they have to be replaced?**
- **Is the current tooling designed strictly for the task rather than conceived with the operator in mind?**

If the answer to questions like these is “yes,” an investment in 3D printed tooling can pay dividends.

Manufacturing – Production and Supply Chain

3D printing possesses many unique capabilities compared to conventional manufacturing technologies and these advantages are becoming more well-defined and understood. This increased knowledge is allowing companies across a growing number of industries to employ additive manufacturing to bring new products to market, reduce production costs, diversify supply chains and streamline their operations.

Because 3D printing is an additive process, there are far fewer restrictions on what geometries can be produced compared to molding, machining, and forming processes. Companies are taking advantage of these design freedoms and bringing new and advanced products to market that would have been cost-prohibitive or simply not possible to manufacture otherwise.

Another advantage is that additive manufacturing can print many different parts within a single production run with no need for the fabrication and installation of costly tooling. This flexibility and scalability is something conventional processes often lack because recouping the cost of the tool requires production runs of many thousands of parts. In contrast, additive manufacturing is an agile, lower-volume production solution that does not depend on economies of scale. This opens up new opportunities where lower production volumes were previously uneconomical.

3D printing also has the potential to upend traditional supply chains. Its digital nature eliminates the physical limitations of the hub-and-spoke manufacturing and distribution model where goods are produced in a factory, then shipped to distribution and retail locations. The ability to locate 3D printers at or close to the point of use shortens the supply chain, bypassing links that can break down and impede traditional manufacturing and distribution networks, enabling on-demand production.

3D printing's ability to keep supply chains operational was illustrated in the fight against the COVID-19 pandemic. Stratasys and a coalition of industry partners pooled 3D printing resources to manufacture over 100,000 face shields for frontline medical workers at a critical time before high-volume injection molding production could be brought on line.

Manufacturing – Production and Supply Chain

Investment and Implementation

To successfully implement additive manufacturing within your manufacturing supply chain, you must consider both product strategy and business operating model.

Additive manufacturing can support and advance your product strategy by speeding time to market, enabling you to out-compete rivals or keep pace with customer trends. Through enhanced design freedoms, it can also open up new opportunities for customization, modularization, and superior efficiency. As an on-demand production technology, it can produce end-use parts and support operational improvements across your business, such as preventative maintenance, increasing machine throughput, reducing assembly procedures, or lowering tooling costs.

Making the case to invest in 3D printing for manufacturing comes down to determining whether its benefits align with your company goals. This includes assessing your supply chain for areas of improvement and the business viability of lower-volume and on-demand production.

> **Things move as fast as the least lucky and least competent supplier you know.**
>
> **Elon Musk, CEO of SpaceX and Tesla**

Sales and Retail

3D printing is seeing greater adoption in the retail space. The reason has to do with the "experience economy" – the idea of adding customer value through an entertaining, memorable or personalized transactional experience. 3D printing enables brands and retailers to experiment and innovate across the customer journey, delivering new products and new experiences.

Take "co-design," where customers help design their purchase by changing features, geometry or other characteristics. Their unique product is subsequently 3D printed. In addition to opening up more products for customization, a co-design experience elevates the role of the customer into a pseudo-designer, giving them a deeper connection to both the product and the brand.

Another opportunity is serving markets-of-one. Technology is driving expectations of personalized and on-demand experiences. This is forcing traditional players to reinvent their organizations to better capture these opportunities as they arise. 3D printing provides the means for retailers to serve these "momentary markets" by accelerating product development and production setup or even switching to direct additive production to deliver localized products or limited editions to meet these niche trends.

When selecting an additive technology for sales and retail, it is just as important to consider the aesthetic and usability aspects of the printer. If the intent is to position 3D printing within the retail environment, either to produce parts for sale, or to provide experiential value, consider the size and operation of the printer. Can customers clearly see the printing process? Can retail staff be trained to operate it? Can the printer produce parts fast enough to fulfill an order?

Bulleit Bourbon / 3D printed bourbon cocktails printed at the bar, where customers were able to create a unique pattern into their drink

Sales and Retail

Investment and Implementation

Investing in 3D printing to support your retail and sales activities requires careful consideration both in the method of deployment and how value is recognized. Benefits that 3D printing can bring to this space are intangible so it is critical to clearly establish KPIs to accurately assess your ROI.

3D printing will likely be a new concept for many individuals from store workers to marketing managers, all of whom may have contact with the technology. Implementation steps should include educating your staff about this technology so they can effectively support and champion its deployment.

> **“The only companies that will exist in 10 years’ time are those that create and nurture human experiences. This learning and growth will come from maximizing opportunities, including the reinvention of retail spaces, new models of engagement, and an understanding of experiences as perhaps the most important form of marketing**
>
> **World Economic Forum Annual Meeting 2019**

Maintenance and Aftermarket

3D printing is becoming increasingly relevant in the aftermarket space, as companies look to cut costs in tooling, storage and setup, and seek to find new and innovative distribution and repair models for spare parts. Where businesses embrace 3D printing to produce spare and replacement parts, entire storage warehouses can be replaced with a bank of 3D printers, producing parts on a just-in-time basis, or even replaced with a service bureau.

Often, the problem with producing for the aftermarket comes down to achieving efficient production volumes. But the quandary is determining what that number should be and if it runs the risk of either over- or under-producing. 3D printing solves the problem by providing a production mechanism that is efficient across any volume. But economic low-volume production is only half the story. When you design and produce parts via 3D printing, you gain the ability to produce at low volumes anywhere – in house or at a service bureau. Concepts like centralized repair depots that produce or repair parts and incorporate them into rebuilds become possible. Remanufacturing one-off parts for an obsolete product line using 3D scanning and advanced engineering is now an option.

In short, 3D printing aids both makers of aftermarket parts and maintenance and repair organizations through on-demand inventory, digital tooling, repair aids and re-engineering.

Investment and Implementation

Using additive manufacturing for maintenance and aftermarket will necessarily touch many business areas, including product development, manufacturing, customer support, and distribution. Naming not just executive level champions, but also leaders within each business unit who can drive, coordinate, and coach, will be paramount to any initiative's success.

Considerations such as product lifespan, storage needs, regulatory requirements for product support and part reparability all factor into the decision on whether to invest in 3D printing for aftermarket and repair operations.

3D printing makes aftermarket production support economically viable and time efficient for Siemens' Mobility division. The company uses the technology to make on-demand rail car replacement parts like this driver seat armrest.

//Chapter 04

Valuing 3D Printing Investments

Every business investment starts with the business case. So how do you make a compelling business case for 3D printing? It starts by looking beyond the more simple task of justifying the purchase of the printer. Too often, businesses add up the cost savings a new printer achieves relative to the traditional manufacturing process it replaces. But this comparison is far from a fully developed business case for adopting 3D printing.

Focusing solely on piece-part cost reduction means you'll miss 90% of the iceberg. Certainly, hard cost-reduction numbers are part of the justification equation. But sometimes the business case also needs to include scenarios portraying the future possibilities and order-of-magnitude estimations.

From Incremental to Transformational Value

How your organization derives value from 3D printing will depend on how and to what ends the technology is deployed. Some businesses will derive value from incremental replacements and improvements to parts and processes, while others will use the technology to enable transformative change in their businesses, enabling new products and services never before possible.

> **...on average, companies that implement effective capability-building programs as part of their transformations are 4.1 times as likely to succeed than other companies**
>
> McKinsey 2017

Substitution

The simplest case for assessing 3D printing's value involves substituting conventional processes and parts with 3D printing to reduce costs. Substitution can make sense in cases where the economics of traditional production make it less attractive than additive.

Benefits from substitution usually come in the form of reducing fixed costs of production. Sourcing, production setup, tooling, and other fixed costs may make 3D printing highly attractive, especially at lower volumes.

Augmentation

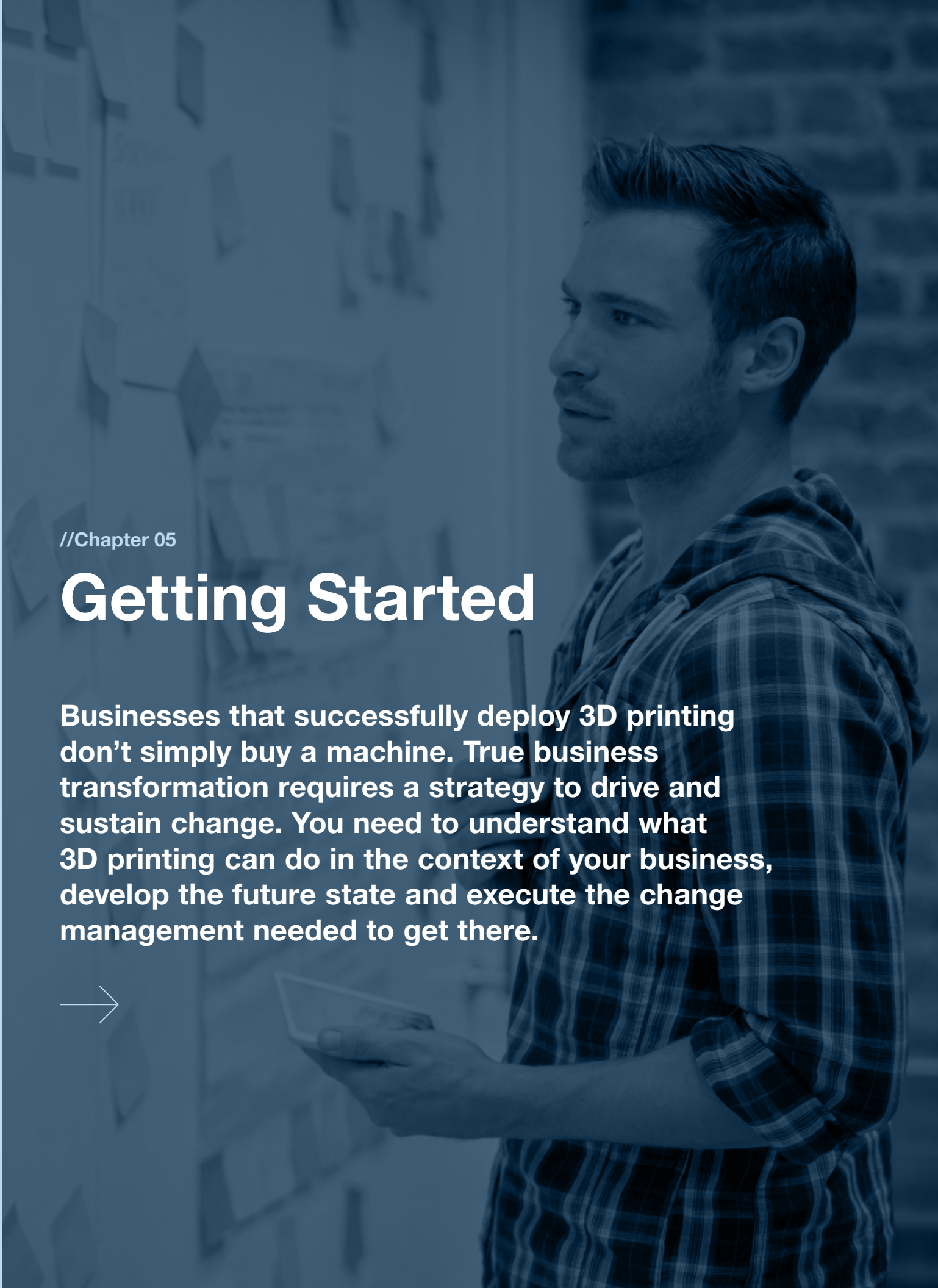
Many businesses have discovered that 3D printing lets them do the things they do, but do them better. 3D printing can automate manual processes by converting physical work into digital manipulation. It can also produce more robust products through assembly consolidation.

Gains from augmentation result from increased efficiency and lower lead times, or improvements that lead to simpler processes or more robust and functional products.

Transformation

Whether it's new avenues of personalization and customization or completely new ways of delivering products, 3D printing can create opportunities for new product categories, new ways of servicing customers, or fundamental changes to how products are made.

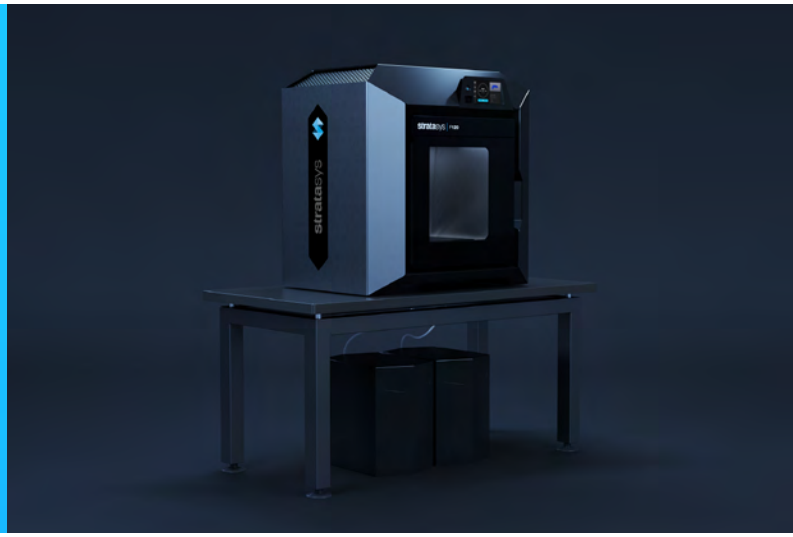
Because 3D printing can enable entirely new business and product lines, in a transformational 3D printing initiative, most of the value will come in the form of revenue growth, new market opportunities and new business models.



//Chapter 05

Getting Started

Businesses that successfully deploy 3D printing don't simply buy a machine. True business transformation requires a strategy to drive and sustain change. You need to understand what 3D printing can do in the context of your business, develop the future state and execute the change management needed to get there.



Properly deployed, 3D printing will also challenge the ways that program management, designers, engineers, and procurement have traditionally operated. Conventional methods of design, purchasing, ROI calculation, and supply chain configuration won't work when adopting additive; your organization must be prepared to break down the status quo and start thinking additively. Also, to sustain the initiative, KPIs should be developed that encourage adoption of 3D printing. Most likely, your current metrics will be tailored to optimizing existing business processes. Re-evaluate these metrics and ensure they provide incentives to take risks, experiment, and discover new opportunities for value creation that 3D printing can provide.

To deploy 3D printing throughout your organization, the journey must be leadership driven. Leaders must define 3D printing as a business priority, develop the strategy, and provide the resources to build an ecosystem and enable people. Perhaps more important, leaders must build a culture that is willing to change in pursuit of the better and provide incentives that sustain that culture.

Summary

A Different Manufacturing Paradigm

3D printing is unlike traditional ways of making things. Being additive rather than subtractive, it breaks the link between a part's complexity and the cost to manufacture it. Economies of scale don't exist either because it's a digital technology that doesn't rely on tooling. This makes lower-volume production viable. And since parts can be produced wherever there's a 3D printer, production isn't reliant on traditional factories, making supply chains shorter.

There are Reasons it Makes Business Sense

This different way of manufacturing is backed by several business drivers, all of which ultimately result in a positive bottom-line impact:

- Design freedom – Parts can optimized for the design purpose rather than limited by the restrictions of traditional manufacturing constraints.
- Embedded functionality – 3D printing allows for the inclusion of added capabilities within a part or assembly, eliminating manufacturing steps, lowering cycle time and reducing cost.
- Streamlined supply chains – On-demand capabilities and point-of-use production short-circuit traditional supply chains, speeding delivery and reducing inventory costs.
- Personalization – With the encumbrance of economy-of-scale out of the picture, personalization can go mass-market, allowing greater market differentiation.
- Cost-efficient manufacturing – The absence of tooling requirements eliminates one of the largest manufacturing costs, making lower-volume production cost effective.
- Life-cycle sustainability – Design freedom and point-of-use production allow for lighter, optimized parts that save fuel use and reduce environmental impact.

Adding Value Across the Product Lifecycle

Most importantly, 3D printing can make an impact at every stage of a product's life. That includes prototyping, tooling, manufacturing, sales and retail, and maintenance and aftermarket support. Leveraging its broad application and valuing it as a transformational technology gives you the opportunity to maximize all this technology has to offer.

Stratasys Can Help

3D printing is a proven technology that gives companies the tools to grow their business and improve their competitive position. That includes companies as diverse as Bombardier, Whirlpool, Siemens, GE, Pratt & Whitney and a host of others, large and small. But making 3D printing a part of your business doesn't mean you have to go it alone. We can help.

Stratasys has been providing 3D printing solutions for over 30 years. We understand that businesses have varied needs relative to the implementation of this technology. Our experts can guide the appropriate people in your organization to the right additive strategy for your business.

Contact us today to start the conversation on how 3D printing makes sense for your business.

Visit our website for the appropriate contact information to find a reseller, request a quote or talk to our team. Or simply email us at transformationteam@stratasys.com

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