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Integrate 3D Printing into Digital Manufacturing

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Companies racing to embrace the future of manufacturing can get there faster using rapid prototyping, rapid tooling, and additive manufacturing.

As digitalization continues to upend the manufacturing sector, 3D printing is taking on a new role—not just for fast and cost-effective prototyping—but also as a viable mainstream production technology.

Like other industries, manufacturers are rapidly expanding digital connectivity throughout their ecosystems and creating new digital processes that support the entire product lifecycle. These digital connections leverage 3D models to sync a manufacturer's designers, engineers, partners, factory workers, maintenance personnel, and end users to a common framework for collaborating and sharing data that can unlock enormous value and change the manufacturing landscape. Digitization will have an impact on every aspect of manufacturing, from early concept design to operations and throughout the supply chain. By supporting new digital processes, manufacturers are seeking to bolster innovation, capitalize on sourcing and production efficiencies, and facilitate preventive and prescriptive maintenance while improving their customers' experience.

3D printing has been a mainstay of engineering departments for decades as a rapid prototyping tool, but the technology is now being tapped more readily for production applications thanks to breakthroughs on a number of fronts, including the ability to print larger parts and an expanding range of robust materials. Manufacturers embracing 3D printing as a production technology stand to benefit in a variety of ways. For one, they can more quickly turn digital designs into physical products, helping meet the growing demand for mass customization and shorter design cycles.

At the same time, integrating 3D printing into the product development workflow facilitates the product design and development process, whether it's for prototyping, expensive tooling or final-production products. Unlike traditional workflows, where engineers design products and then figure out the best way to manufacture them, 3D printing, as part of a digital manufacturing approach, removes those barriers and reduces design constraints to promote greater innovation while accelerating time to delivery.

"Every engineer learns to design with the limitations of manufacturing processes in mind," says Scott Sevcik, vice president of manufacturing solutions for Stratasys. "If we can use 3D printing to reduce the constraints that inform the part design, we enable greater design freedom."

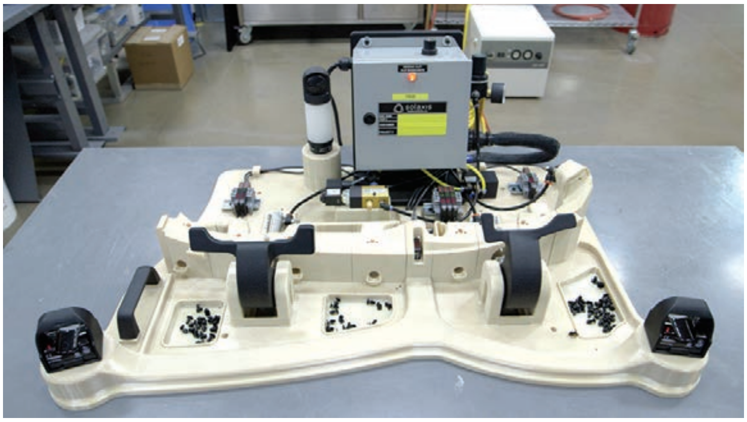
The Power of 3D Printing

On the rapid prototyping front, manufacturers already have a good deal of experience integrating 3D printing into their design workflows. The ability to quickly produce a physical part gives engineers a much better perspective on how an evolving design will look, function, and interact with other parts in a system. Engineers can leverage the growing number of material choices and color options to create realistic prototypes that make it easier for non-engineers to give feedback and participate in the iterative design process. Moreover, seeing a design's physical representation before it's finalized helps eliminate potential integration issues later, allowing the extended team to focus attention on the most promising iterations or to improve imperfections on concepts that simply require a bit of fine tuning.

One area where 3D printing has been often overlooked, but has provided immense benefit for those that have discovered it, is for production of expensive manufacturing tooling, including jigs and fixtures. Conventional manufacturing of complex parts and tooling is typically constrained by equipment capabilities, in most cases, milling cutters and drills. In contrast, 3D printing can be leveraged to quickly create tools optimized for their intended use, greatly speeding up the process and reducing costs by eliminating extra steps for fastening and welding. 3D printed tooling can also result in more lightweight, organic designs compared to those produced using conventional manufactured industrial equipment, reducing wear and tear on the overall system or the operator. Due to the ease and flexibility of the 3D printing process, tooling can be quickly refined, ensuring continuous improvement of the production process. In this manner, manufacturing engineers can quickly identify and make ergonomic improvements to tooling, bolstering cycle time and positively impacting yield.

Volvo Trucks replaced metal tooling for its engine production facility with lighter 3D printed tools and fixtures created on a Stratasys Fortus® 3D Production System in production-grade thermoplastic. Since doing so, the plant has slashed its tooling design and production time from 36 days down to two. "3D printing has made an incredible impact on the way we work," says Pierre Jenny, manufacturing director at Volvo Truck's Lyon, France, facility in the e-book *Optimized Production for Additive Manufacturing*. "The capability to produce a virtually unlimited range of functional tools in such a short timeframe is unprecedented and enables us to be more experimental and inventive to improve production workflow."

Beyond assembly tools, forming tools also benefit from 3D printing's advantages. Composite layup tooling is a notable example. While composite



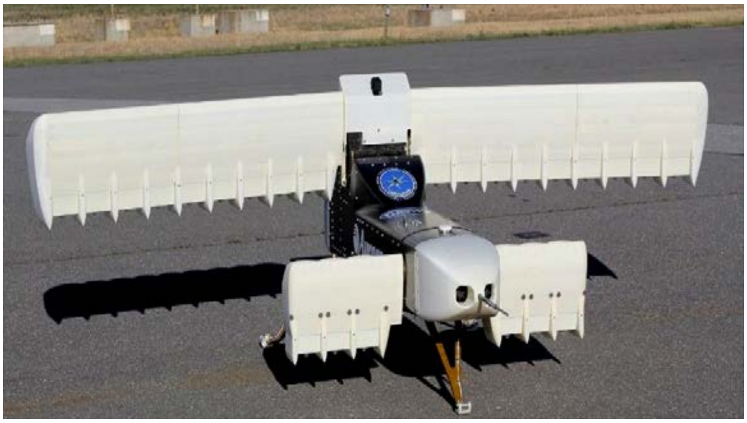
Solaxis created an automotive assembly jig with 3D printing, cutting weight and improving accuracy. Learn more.

structures are lightweight, the tooling used to create them is not. Traditional metal tools and even advanced Carbon Fiber Reinforced Polymer (CFRP) tools are bulky, expensive and time-consuming to produce. This limits the flexibility of composites manufacturers as parts need to remain simple and be produced at volume to amortize the expense of the tools.

In comparison, 3D printed composite lay-up tools made with FDM® (fused deposition modeling) materials can be produced far more quickly and at less cost than conventional methods. This gives composite manufacturers the ability to change

Volvo Trucks replaced metal tooling for its engine production facility with lighter 3D printed tools and fixtures. Learn more.

FDM technology simplifies the fabrication of composite layup mold and sacrificial tooling while providing more design freedom. Learn more.



Aurora Flight Sciences 3D printed major portions of its scaled LightningStrike vertical takeoff/landing demonstrator.

designs more frequently, enabling new opportunities for custom and low-volume production at a cost-effective price point. Finally, the ability to print such tools on-demand means companies no longer need to store tools indefinitely in case a replacement part is needed in the future. The tooling can be stocked digitally and reproduced if need.

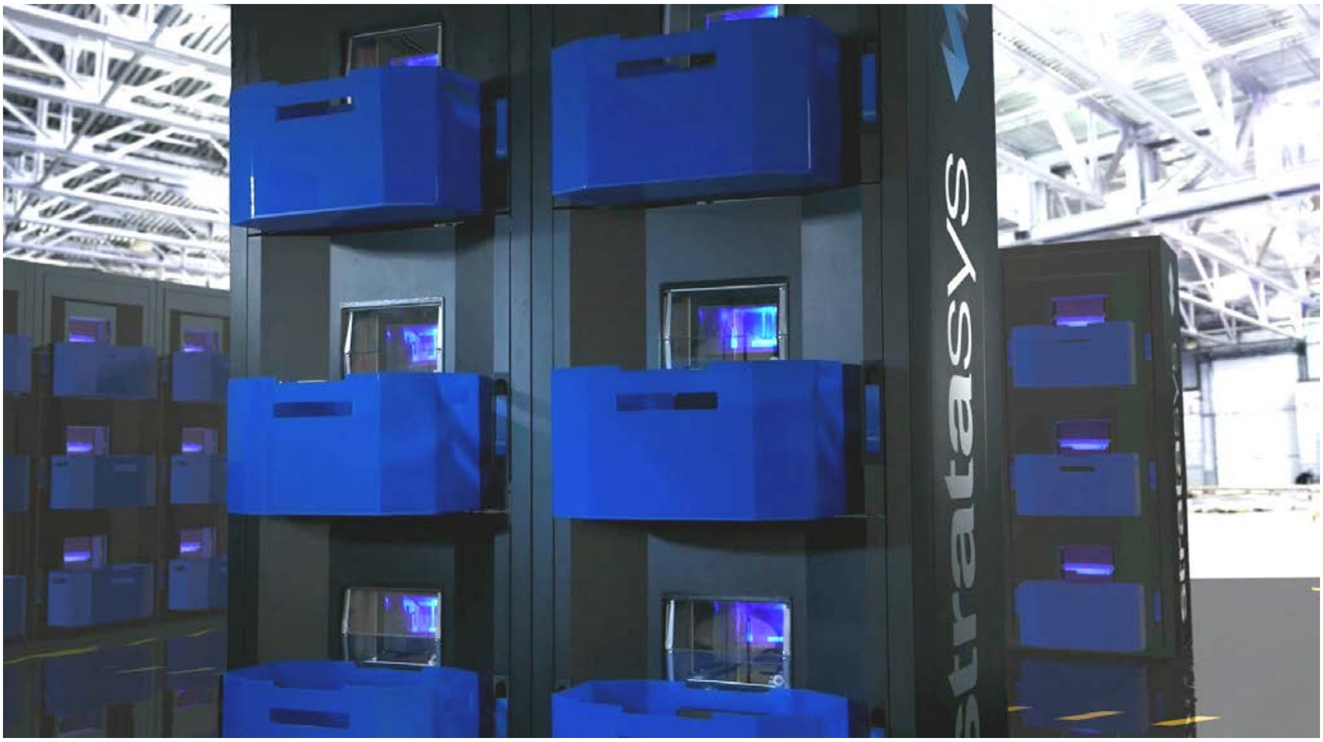
Aurora Flight Sciences (AFS), which designs special-purpose aircraft, traded up traditional composite tooling processes for a new approach that leveraged Stratasys FDM technology. Not only did the company come up with a unique tooling design, it achieved a 60% to 80% reduction in lead time with a 60% to 75% cost reduction, helping it meet the demanding timeline of its customers.

In a growing number of instances, 3D printing is a more effective means of producing production parts for vehicles. For one thing, 3D printing's design freedom makes it possible to achieve lightweight designs. Organic shapes that aren't attainable with conventional manufacturing methods are possible with additive. Multiple parts in an assembly can be combined into a single part, saving time and materials while reducing supply chain and assembly risks. The technology is also far better suited to accommodate mass customization compared to traditional manufacturing methods, opening up new revenue streams for companies willing to take the plunge.

Unlike conventional casting or molding, 3D printing can accommodate the features of next-generation designs, including variable lattice densities, hollowed out or partially filled internal structures, which are increasingly used to reduce part weight or bolster product performance. More advanced 3D printing techniques also let engineers specify material properties at a granular level, giving them greater control over part quality and performance.

In addition to being well-suited for pilot and low-volume productions runs, 3D printing capitalizes on near-ubiquitous connectivity to digitally distribute production across facilities, even across the globe. In this scenario, a manufacturer can leverage supply chain advantages by distributing part production to another facility to better accommodate peak demand periods. They can also easily change production from one product to another without retooling a manufacturing line, a process that adds significant time to the cycle. Environmentally conscious manufacturers can take advantage of the ability to shift production closer to the point of sale as opposed to being limited to specific production facilities. In that way, they don't incur the cost and energy output associated with far-flung distribution and extended supply chains.

"With a digital manufacturing approach leveraging 3D printing, companies are able to make decisions and have flexibility in the supply chain



The Stratasys Continuous Build 3D Demonstrator automatically cues jobs to print, ejects completed parts and starts the next job without interruption, increasing efficiencies and opening up more time for tasks unrelated to managing the 3D printing process. [Learn more].

to shift production to different locations," Sevcik explains. "This enables companies to meet needs as they arise, which was previously unthinkable."

3D printing spare parts offers efficiencies over traditional manufacturing. Historically, manufacturers anticipated what they required in spare parts over the course of years, maybe even decades, produced those volumes, then stored and distributed parts as needed. If inventory ran out, they initiated another manufacturing run, often at great expense with significant lead times. An alternative approach is to eliminate aftermarket inventory, 3D printing only what's required on-demand instead of maintaining costly maintenance, repair and operations (MRO) stock.

The Digital Future

As the digital thread winds its way through product design and into manufacturing and maintenance, 3D printing will become even more prevalent as a production process. 3D printing eliminates the barriers between the digital and physical worlds, unlocking the promise of digital manufacturing. The digital thread will be extended as part of an integrated workflow where parts are designed and simulated as 3D models with production behavior modeled in a parallel process, providing full traceability on design and manufacturability. Advances in software and artificial intelligence will allow some of the 3D printing process to be automated, simplifying operation and creating additional optimization and efficiency opportunities.

While 3D printing won't ever fully replace conventional manufacturing practices, the approaches will be further refined to co-exist effectively as part of a hybrid manufacturing strategy. "You have to view 3D printing as another tool in the toolbox," says Sevcik. "We're going to see more integration of workflows where you use traditional manufacturing for certain parts and 3D printing for others."

Additional Resources

- 3D Printing vs. CNC Whitepaper
- Assessing the Potential for Additive Manufacturing for Lower-Cost Tools in the Automotive Industry
- How Additive and Traditional Manufacturing Mix Whitepaper
- Manufacturing the Future Whitepaper