Quick Answer: Mapping Design for Additive Manufacturing Tools to 3D Printing Use Cases

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Initiatives: Manufacturing IT Optimization and Modernization

As 3D printing gains momentum across manufacturing, active participation from CIOs becomes imperative to scale adoption of the technology. To help teams produce and optimize complex designs, CIOs must understand which design for additive manufacturing tools are available and when to apply them.

Quick Answer

Which design for additive manufacturing (DFAM) tools should CIOs prepare to support when deploying 3D printing (3DP)?

- **Generative design:** Ideal for new designs or products, this AI-based tool helps develop product designs that are optimized for weight, cost, strength and materials, thus producing the most relevant solution for a specific combination of goals and constraints.

- **Topology optimization:** Targeted at existing digital assets that can be 3D-printed, this tool optimizes design in a specified region of the product to minimize weight and maximize performance.

- **3D scanning:** A practical solution for parts that are no longer in production, 3D scanning reverse engineers existing physical objects to create digital models, thereby enhancing business resiliency.

More Detail

Additive manufacturing is ideally suited to producing complex parts that cannot be manufactured through traditional processes, because each layer is built on top of another layer, resulting in design and production flexibility. Complex 3D-printed parts change the value proposition of the manufacturing organization's business model by enabling new product design development with innovative physical capabilities. However, scaling these 3DP efforts requires IT, operational technology (OT) and engineering technology (ET) alignment — a challenge that manufacturing CIOs are struggling to overcome.

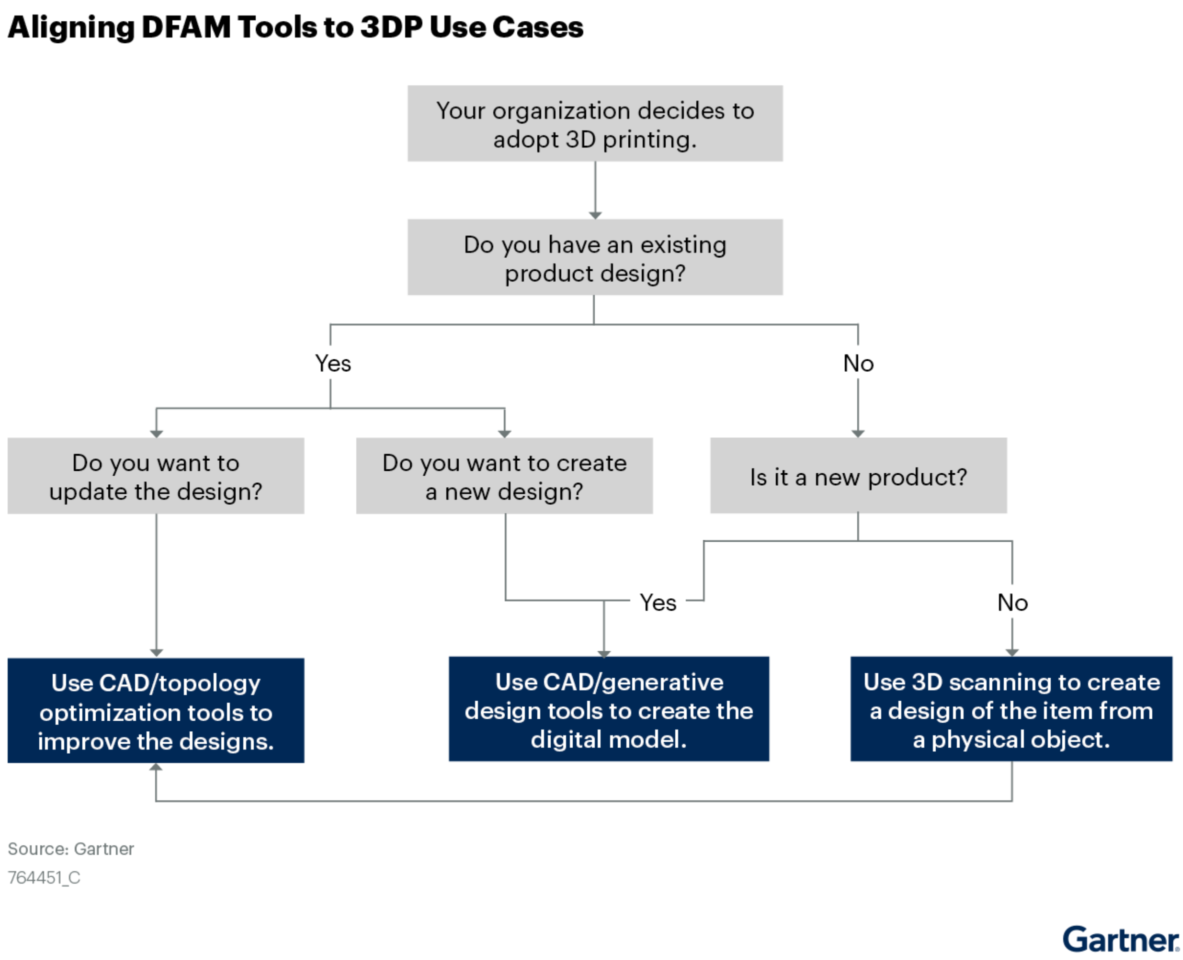
As a first step toward this alignment, manufacturing CIOs must understand what DFAM tools are necessary and when to apply them to different 3DP use cases (see Figure 1). In addition to computer-aided design (CAD), the traditional design tool, the following DFAM tools are now being utilized for 3DP use cases, such as designing prototypes; designing tools, jigs and fixtures; and designing production parts:

- Generative design
- Topology optimization
- 3D scanning

Through the adoption of these innovative design tools, manufacturers have been able to create complex parts with optimized designs. These optimized designs decrease weight and increase air flow, thereby reducing cost and improving product efficiency. The reduced assembly complexity leads to part consolidation as well, thereby enhancing production and supply chain efficiency.

Subsequently, CIOs need to proactively support leaders involved in the adoption of 3DP by guiding them on what the right DFAM tools are and how they perform. Additionally, CIOs must make leaders aware of how important it is to integrate these tools into existing enterprise applications, such as ERP and PLM. Further, CIOs can create a 3DP IT environment by developing and integrating a network of 3DP software and hardware infrastructure.

Figure 1: Aligning DFAM Tools to 3DP Use Cases



Generative Design

Generative design allows engineers to develop designs that are optimized for weight, cost, strength and materials. This iterative process pinpoints the most effective design option, which can then be created through additive manufacturing. For example, one type of generative design based on genetic algorithms allows the engineer to input design goals and constraints into the generative design software. The computer algorithm generates thousands of designs with a performance analysis of each. The user studies the result, accepts it or modifies the goals and constraints, and repeats the process. This combination of human and artificial intelligence (AI) identifies the most relevant solution. The part is then fabricated through additive manufacturing or conventional processes (if possible).

For example, General Motors (GM) used Autodesk's Fusion 360 generative design software to create a seat bracket (a vehicle component where seat belts are fastened). The engineers at GM set product parameters such as strength, mass and connection points in Fusion 360, which created over 150 design options. The final option selected had a unique design and consolidated eight subcomponents into one part, making the 3D-printed output 40% lighter and 20% stronger than the original part. [1]

To scale 3DP adoption, manufacturing CIOs should partner with departments, such as engineering, operations, supply chain and finance, to evaluate 3DP opportunities. They need to facilitate the data flow for generative design applications across internal departments by clearly articulating the role that IT plays in scaling end-to-end-solutions. This support will not only lead to the design of innovative products, but also reduce their time to market.

Topology Optimization

Topology optimization software has helped engineers and designers run simulations that modify surface geometry to minimize stress and strain while maximizing durability. This software optimizes design in a specified region of a product so that the material is efficiently distributed to minimize part weight and maximize performance. However, the potential of this software is harnessed especially for 3D-printed products with complex lattice structures that cannot be manufactured by conventional means. [2] Engineers can design complex parts for 3D printing that would otherwise require a more costly assemblage of many parts.

For example, BMW leveraged a topology optimization software to design a roof bracket, a product that assists in folding and unfolding the roof of a vehicle. In order to maximize performance, engineers at the company input product specifications such as weight, size and maximum load. The optimized design could not be created through traditional manufacturing processes and needed to be 3D-printed. The final 3D-printed part was 10 times stiffer and 44% lighter than the nonoptimized product. [3]

If organizations already have an existing digital asset that can be 3D-printed, CIOs need to prepare their 3DP IT environment by developing and integrating a network of 3DP software and hardware infrastructure. By supporting and promoting the adoption of topology optimization tools, they will enable engineers to target design improvements in a specified region of an asset, thereby reducing its weight and enhancing its performance.

3D Scanning

3D scanning is a growing activity that supports organizations adopting 3D printing as a strategic technology. Scanning physical objects is a first step to creating model parts that can be 3D-printed. 3D scanning technology produces point clouds that can be converted to surface models and solid models suitable for digital twins. Manufacturing enterprises can leverage 3D scanning technology in product design, rapid prototyping, reverse engineering and digital twins.

For example, the Kawasaki Puccetti Racing team leveraged 3D scanning to create a 3D model of Kawasaki's racing motorcycle. The model was then further optimized using aerodynamic modeling algorithms to allow the motorcycle to reach higher speed. The optimized complex model was then 3D-printed with carbon fiber, which increased the motorcycle's speed by up to 4 km per hour. [4]

To increase business resiliency, manufacturing CIOs should promote the use of 3D scanning, which enables reverse engineering, to create digital assets of parts that are no longer in production.

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Evidence

[1] General Motors: Driving a Lighter, More Efficient Future of Automotive Part Design, Autodesk.

[2] Design for Additive Manufacturing: Guidelines and Case Studies for Metal Applications (PDF), Fraunhofer Institute for Machine Tools and Forming Technology.

[3] Application Spotlight: 3D-Printed Brackets, AMFG.

[4] Kawasaki Puccetti Racing Takes Pole Position Using 3D Printing And Scanning Technology, 3D Printing Industry.