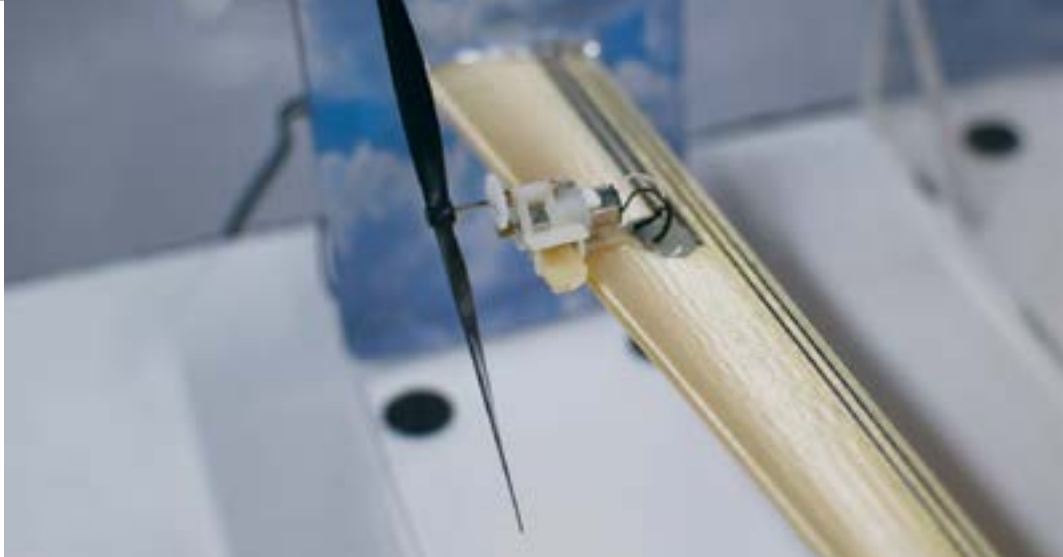




# Transform Manufacturing By 3D Printing End-Use Parts



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Manufacturing is experiencing a digital transformation with the advance of 3D printing in modern manufacturing facilities. The current strategic imperative is to embrace the breakthrough potential of 3D printing by integrating digital into your organization's structures, processes, systems and incentives.

## How So?

New technologies are typically deployed to augment current methods. These new technologies often provide significant speed and profitability improvements. For example, 3D printing has been successfully used for prototyping components and parts.

But for several years now, innovative manufacturers of all sizes have realized significant value applying 3D printing to mainstream operations, both as an alternative and complement to traditional methods.

Manufacturers are applying these new capabilities to:

- Design and build new and better products
- Accelerate product time to market
- Lower production time and costs 70 to 90 percent in targeted applications
- Respond to customer demands that were previously impossible
- Innovate supply chain changes to create competitive disruption in their markets



Build small lots of parts, even one-off parts, without concern for setup and changeover.



Combine multiple parts, in any combination, for building.

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Maximize throughput with multi-part builds.

Developing strategic applications requires innovation. This occurs when organizations have experience gained by applying technology to basic usage. Ultimately, with 3D printing, this can lead to product, operations process and business model innovations that create breakthrough opportunities for experienced, insightful organizations.

Using 3D printing for replacement applications is simple and extremely cost-effective. Manufacturers would be wise to capitalize on opportunities to incorporate 3D printing in general – and end-use parts in particular – into their production processes.

## Defining Terminology

3D printing, end-use parts and FDM® are important terms for this paper.

The term 3D printing – also called additive manufacturing – is the process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies. Using additive processes, successive layers of material are laid down under computer control. 3D printing describes technologies that can be used throughout a product's life cycle.

An end-use part is any tangible good that is sold as product, used as a sub-assembly or as a component in a product. End-use parts are also placed in service within the company's own operations; for example, a component used on its packaging equipment.

FDM, or fused deposition modeling, is a type of 3D printing where lines of molten thermoplastic are extruded from 3D printers. These materials then solidify exactly as they are deposited. Manufacturers are embracing FDM as an alternative to traditional manufacturing technologies, such as injection molding and machining for low-volume and customized parts.



Optimize the orientation and pack of a build for maximum throughput, like these polycarbonate parts.

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## FDM End-Use Parts

FDM technology is used to 3D print end-use parts across the entire product life cycle. In the early phases of product release, it can be used to make parts for pilot production runs.

Once the product has been validated and all component designs are frozen, FDM technology is used as a bridge to production: end-use parts are 3D printed while waiting for ramping of tooling and manufacturing equipment and processes.

For more complicated geometries and custom solutions, full production using FDM technology is the practical option. Since traditional tooling is aimed at production of a single design, FDM technology is an efficient and optimized solution for products that are continuously changing – either through product revisions or through order-by-order customization.

When a product approaches end of life, companies should once again turn to FDM technology. As orders decline and tooling requires replacement, FDM technology is an alternative that extends the product life with minimal expense or inventory. FDM technology can also continue to manufacture spare parts even after products are retired.

## FDM Best Fit

Traditionally, parts are manufactured using processes such as molding, casting and machining. For each of these processes, the primary focus is on how to design for capability, optimization and efficiency. Because of this, once the process has been developed, it is static. Changes increase costs, drop throughput and lower manufacturing efficiency.

FDM technology avoids these problems. With FDM



This redesigned FDM tool consolidates most components.

technology, designers gain design freedom. Parts can be designed to optimize for function, not the manufacturing method. This includes the ability to consolidate part count by reducing a multi-part design to either a consolidated or single part design.

FDM technology is a best fit when production volumes are anywhere from a quantity of one to 1,000, and the designs are moderately to very complex. FDM technology also facilitates a dynamic production environment that encourages continuous improvements and design modifications. This flexibility enables companies to expand their product lines to serve markets with tailored solutions. Often this involves a design that is impossible or impractical to manufacture with traditional methods. In this way, low-volume manufacturing becomes practical, affordable and efficient.

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## Design Freedom On The Fly

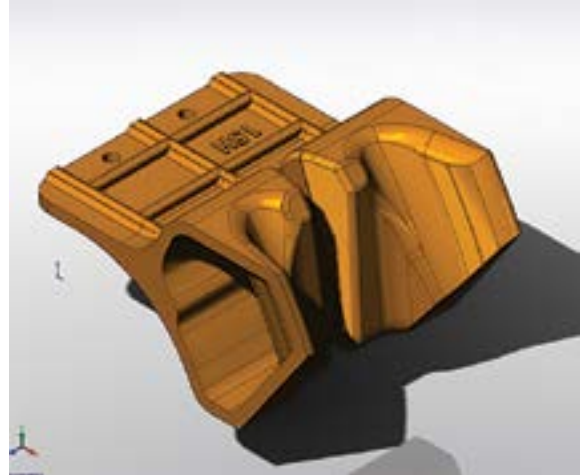
Nova Tech Engineering (NTE), based in Willmar, Minnesota, produces automated machinery for use by poultry hatcheries worldwide. A key part of the company's success has been its ability to customize its machines to manage numerous types, breeds and sizes of birds. However, as the business grew, the cost of machining numerous part variations became increasingly inefficient, costly and growth-inhibiting.

"We were spending a lot of time and money machining parts, which was detrimental to our overall operational efficiency," reflected mechanical designer Jacob Rooney. "Today we use 3D printers for various applications such as rapid prototyping, creating casting molds, thermoforming, jigs and fixtures, and manufacturing finished parts."

A key advantage for NTE is design freedom. "FDM is the perfect fit for us," added Rooney. "It allows us to easily change designs so we can fit the parts to the equipment, and the bird variety at any stage, without being penalized by cost or delays."

NTE took advantage of FDM features such as sparse-fill and self-supporting angles. This reduced materials cost and improved their build times. NTE also benefited from the ability to add design changes on the fly, and to reduce physical inventory by moving it into digital inventory, for print on demand.

With FDM technology, NTE can create the many specialized parts their customers require, but at a fraction of the time and cost. For example, prior to FDM, it took four weeks to produce 10, 12-piece carrier assemblies, at a cost of \$45,000. Today, they take three days to produce at a cost of \$1,500 — a time savings of 89 percent and a cost savings of 97 percent for a single part design. When multiplied by the number of part designs they needed to produce, it quickly justified the investment in the 3D printer.



This CAD model of component for Nova Tech Engineering (NTE) includes features which would be costly and time-consuming to mold or machine.



Numerous variations of this FDM part are needed by NTE's customers for use in their daily operations.

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## Strength And Weight Reduction

Aurora Flight Sciences, which develops and manufactures advanced unmanned systems and aerospace vehicles, fabricated and flew a 62-inch wingspan aircraft — the wing composed entirely of 3D printed components.

The design of the wing's structure was optimized to reduce weight while maintaining strength. "The success of this wing has shown that 3D printing can be used to rapidly fabricate the structure of a small airplane," said Dan Campbell, structures research engineer at Aurora. "If a wing replacement is necessary, we simply click print, and within a couple of days we have a new wing ready to fly."

Aurora also engages in an emerging application: smart parts, which are hybrid parts that include 3D

printed structures and 3D printed electronics. Aurora worked with Stratasys and Optomec to combine FDM and Aerosol Jet electronics printing to fabricate wings with integrated electronics on unmanned aerial vehicles (UAVs).

"The ability to fabricate functional electronics into complexly shaped structures using additive manufacturing can allow UAVs to be built more quickly, with more customization, potentially closer to the field where they're needed. All these benefits can lead to efficient, cost-effective field vehicles," said Campbell.

3D printed smart parts enhance performance and functionality in two ways. 3D printers enable lighter weight mechanical structures. Conformal electronics printed directly onto the structure frees up space for additional payload.

Aurora made this wing entirely of 3D printed components and 3D printed electronics.



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## Summary

Using FDM technology to 3D print end-use parts on demand applies to almost all industries, including consumer products, automotives, aerospace, defense and medicine. Companies of all sizes can benefit due to highly favorable economics at low volume. FDM applies at any stage of the production cycle, both as a complement to an existing process, or as a replacement.

A Deloitte Consulting research report<sup>1</sup> concluded: “As the flexibility of the technology increases, through the addition of materials and processes,

(this will) create opportunities for new products and innovations. In particular, firms that offer products with complex internal geometries that are restrained by technical limitations in machining should pay close attention to developments related to AM.”

Continued the report, “The opportunity for companies to apply AM in the pursuit of value through improved performance, greater innovation and accelerated growth will remain for the foreseeable future.”

Mainstream manufacturing executives are beginning to pay attention to the strategic implications of these compelling and rapidly maturing technologies.

<sup>1</sup>Deloitte Review issue 14, “3D Opportunity – Additive manufacturing paths to performance, innovation and growth.” Written by Mark Cotteleer and Jim Joyce.

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