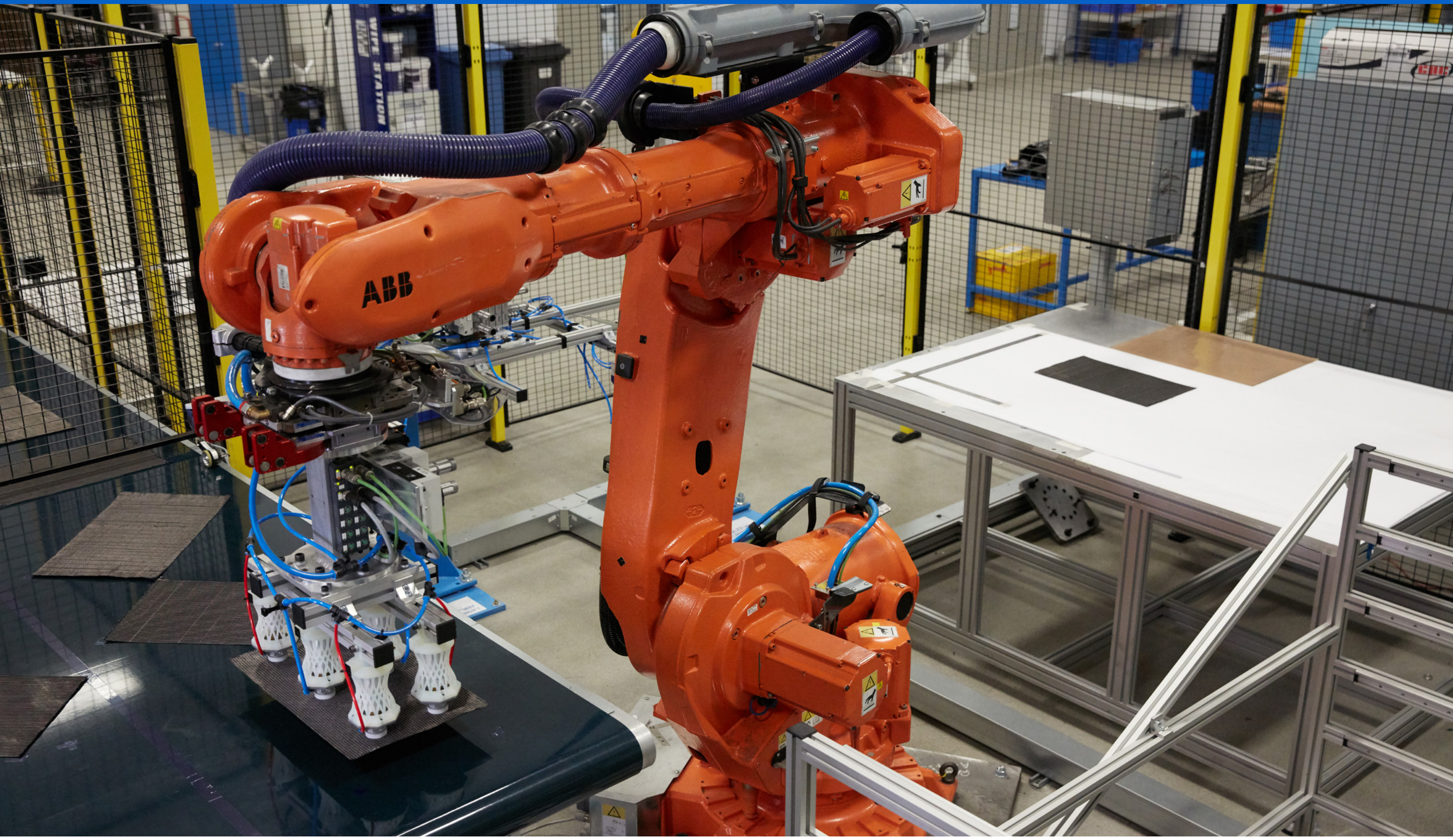

FORMLABS WHITE PAPER:

5 Opportunities for 3D Printing in Manufacturing

3D printing is quietly changing the way that manufacturers produce goods, from reducing the cost of jig and fixture production, to creating end use parts. In this whitepaper, we will look at five common use cases for 3D printing, along with specific examples from manufacturers using in-house stereolithography (SLA) to cut costs, save time, improve quality, and bring new product innovations to market faster.

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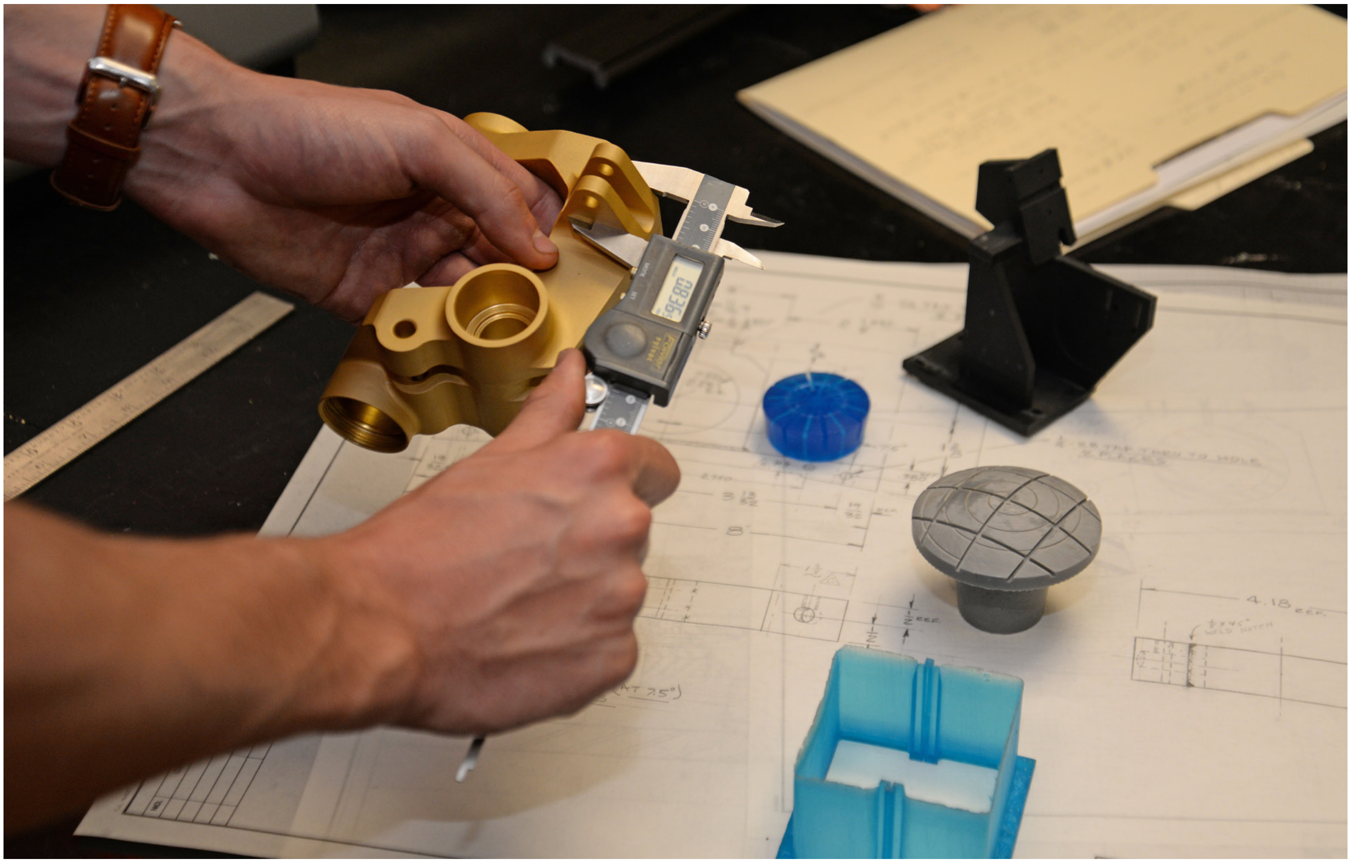
Communication Models

Manufacturers find themselves tasked with creating ever more difficult and complex components. This is particularly true in industries like aerospace, defense, and medical where the state of the art advances quickly and maintaining high quality, tight tolerance parts and assemblies may matter more than cost.

For complicated parts, standard two-dimensional drawings with callouts are sometimes insufficient, leading to confusion and misinterpretation even by skilled and experienced machine operators. 3D printing helps to dispel translation errors by easily replicating the real, three-dimensional geometry of parts and assemblies. Machine operators and assembly technicians can quickly reference the 3D printed copy to avoid costly errors and save time.



Engineers at A&M Tool and Design supplement 2D part and assembly drawings with 3D printed communication models to reduce errors, explain complex operations, and close the loop with customers.

3D communication models are also useful for engineers to communicate with contract manufacturers and vice versa. Engineers want to be sure their contract manufacturers understand part geometries completely and manufacturers want to find opportunities to reduce costs while maintaining product requirements. Using shared physical models gets both parties on the same page, even when moving quickly and iterating on late stage DFM/A adjustments.

CASE STUDY: A&M Tool and Design

A&M Tool and Design is a high precision machining and metal fabricator, building components and assemblies for industrial equipment, robotics, and aerospace applications. With high mix and high complexity, communicating design intent of parts and assemblies is critical to maintain quality and achieve consistent yield.
A&M Tool and Design uses Stereolithography (SLA) 3D printing to produce high resolution communication models for communicating complicated machined parts, weldments, and other assembly designs.

A welder at A&M Tool and Design compares a 3D printed model to the final, full-scale weldment.

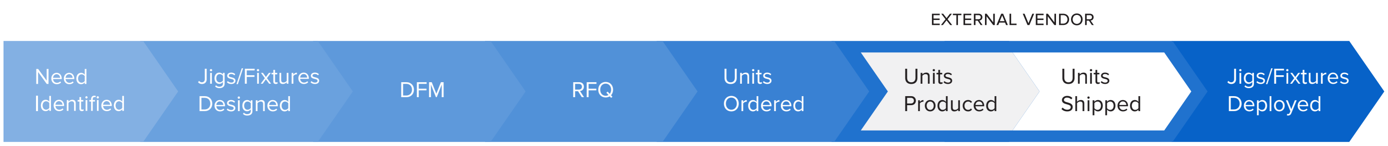
Jigs and Fixtures

Traditionally, manufacturers outsource the fabrication for many of the bits and pieces that support production (like jigs, fixtures, and custom tooling) to minimize organizational overhead and capital expenditure on additional equipment.

Achieving a sensible ROI for producing elements like jigs, fixtures, and tooling internally via traditional manufacturing processes is difficult due to high equipment costs and the requirement for skilled operators. Now that advances in 3D printing technology has improved ROI, more manufacturers are bringing jig and fixture production back in-house. Let's take a look at how manufacturers bring production in-house with an additive-enabled workflow, and the associated cost savings.

The traditional process of creating jigs and fixtures for most companies looks something like this:

1. Identify the need
2. Design the jig or fixture
3. Take that design through DFM process (usually machining)
4. Request quotes from external fabricators, and make any changes
5. Order the parts
6. External vendor produces the parts
7. Parts ship to facility
8. Jig or fixture is added to the production or assembly line



At that point, if any issues or areas for improvement are discovered after the jig or fixture is in use, the process either needs to begin again, or the parts need to be reworked.

An additive workflow is much shorter:

1. Identify the need
2. Design the jig or fixture
3. Print parts in house
4. Jig or fixture is added to the production or assembly line

Addtive workflows for producing jigs and fixtures generally require little to no DFM work, and when production is done in house, there is no need for quoting or days of transportation time for shipped parts.

CASE STUDY: Ashley Furniture

Ashley Furniture's Case Goods division uses alignment pins for locating panel components for CNC routing operations. Their standard vendor for these alignment pins had a minimum order quantity of 1,200 pieces, and charged $10 per part, with delivery to Ashley Furniture in 3-4 weeks. When printing these parts in-house, there is no minimum order quantity, and savings are $4.10 per part. This represents a savings of $4,920 over a single outsourced order.

The ability to distribute capable machines across an organization creates space for greater innovation. By reducing the distance between a production engineer's efficiency-boosting concept and finished parts to nearly zero, experimentation is de-risked, and ideas for improvement can be acted on in real-time.

While currently jigs and fixtures are the most common directly printed manufacturing aids, the use of printed masking for shot peening or coating processes is gaining popularity. Printing custom tooling for robotic end-effectors and heads for CNC benders gives manufacturers more flexibility to create optimal geometries and improve quality.

Engineers can select from a range of printable polymers capable of withstanding high impact, elevated temperatures, and other demanding mechanical requirements. 3D printing jigs, fixtures, and tooling components also presents fewer geometric constraints than molding or machining processes, freeing up engineers to spend more time on innovation and less time on DFM.

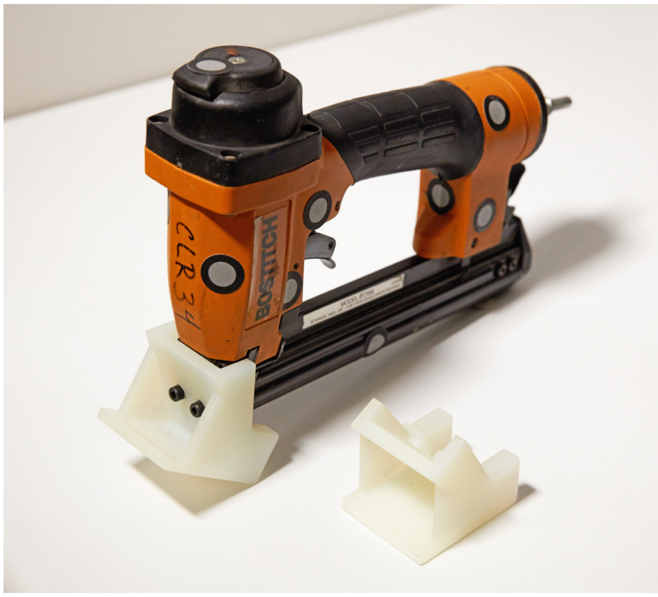
Improving Production with Customized Components

A further benefit of the flexibility that in-house 3D printing affords is the ability to make almost real time changes in production tooling and assembly systems. Many companies have found significant productivity gains and downtime reduction by adopting a more modular approach to their assembly setups, trading out fixed systems for frameworks that incorporate interchangeable 3D printed nodes. Customized non-marring bumpers for assembly nests, and quick-change assembly stations improve production efficiency, increase product yield, and reduce worker strain.

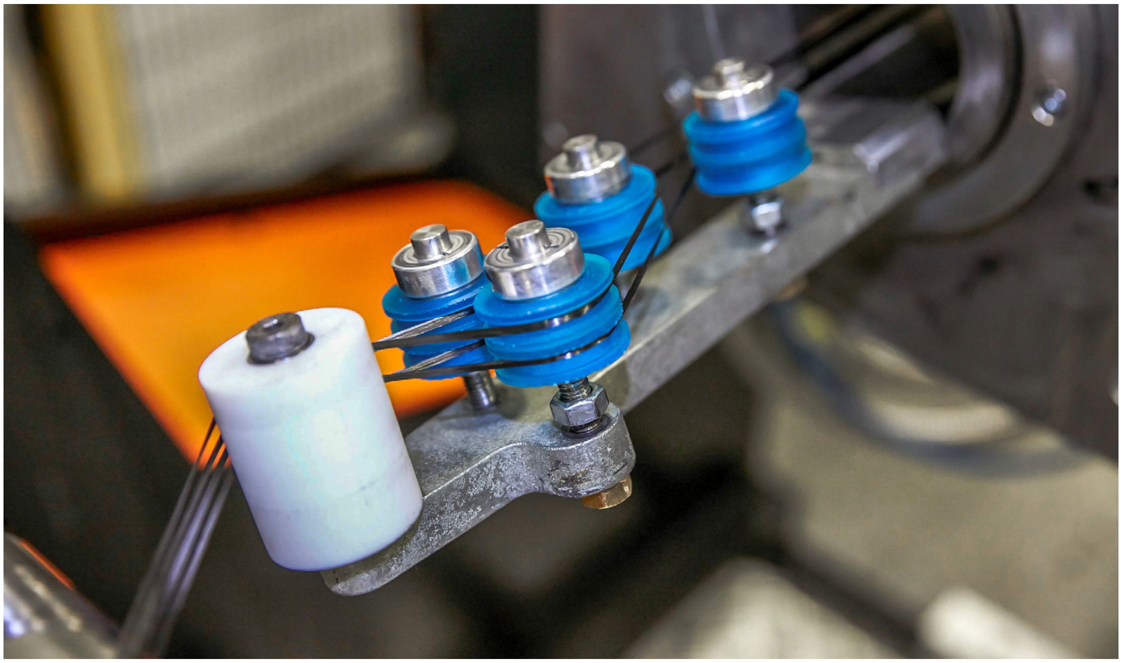
Even more than efficiency gains, responding to operator feedback in nearly real time enables a more collaborative and agile approach to production and assembly. Operators see their feedback acted on quickly, and engineers and toolmakers are able to get their new and improved iterations tested on the production floor in record time. Short design cycles and low part costs mean that manufacturers are free to make improvements more iteratively, helping them implement continuous improvement practices.

Custom Tool Adapters and Process Tools

Ashley Furniture combines CAD modeling and 3D scanning to reverse engineer tool geometries and create custom adapters for nail guns and staplers, improving consistency and repeatability in product assemblies. ▶



Beyond jigs and fixtures, manufacturers often need to create customized parts and mechanisms for their fabrication and assembly processes. Part feeding, alignment tools, end of arm tooling, and maskings all benefit from or require custom parts, but those part geometries can be complex, and carry significant costs for traditional fabrication processes like machining or molding.



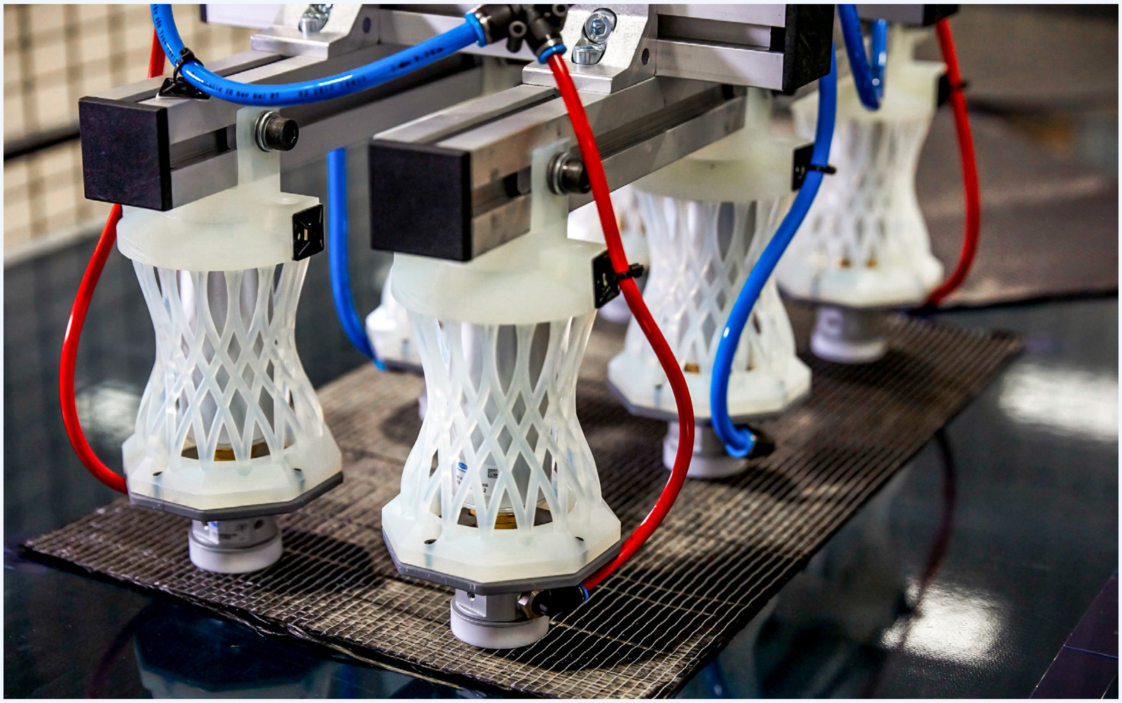
Customized 3D printed filament spools for a carbon fiber manufacturing application at AMRC, printed in Tough Resin.

CASE STUDY: The University of Sheffield Advanced Manufacturing Research Center

The University of Sheffield Advanced Manufacturing Research Centre (AMRC) helps aerospace, automotive, and equipment manufacturers develop the tools and techniques to stay competitive and improve processes. Whether it's advanced machining, manufacturing, or materials, AMRC helps over 100 industrial partners including Boeing, Rolls-Royce, BAE Systems, and Airbus. These business partners approach the AMRC with specific challenges, and AMRC researchers use the newest technologies and processes to develop concepts and solutions to the point where the partners can implement them in their factories.

In one project, researchers needed to automate moving carbon fiber plies with high accuracy and speed using a pick and place robot. After prolonged use, however, the L-brackets that held the robot's compressed air grippers started to bend around the joints which lead to failures and forced the researchers to look for a new solution.

Engineers were able to develop a new, 3D printed design that avoids those problems and is simple to manufacture in far less time than could have been done with traditional prototyping processes like machining. Engineers were able to fabricate and test multiple iterations of the grippers, arriving at a design that exceeded the performance of previous weldments and machined parts. Advanced manufacturing processes often require customized elements to maintain quality and maximize uptime: custom part aligners, stock feeders, and end-of-arm tooling, customized geometries perform better than off-the-shelf solutions and are rapidly built in-house with 3D printing.



3D printed end of arm grippers, made with Formlabs Durable Resin, are used to accurately and repeatedly place carbon fiber plies as part of a composites manufacturing process.

Manufacturing Validation

In the final stages of product design, it's critical to evaluate and de-risk the manufacturability of each component and assembly. Today, many engineers are finding 3D printing an invaluable tool for various manufacturing validation applications, like creating quick-turn, low cost tooling, building custom testing jigs, or creating other components for testing manufacturing processes.

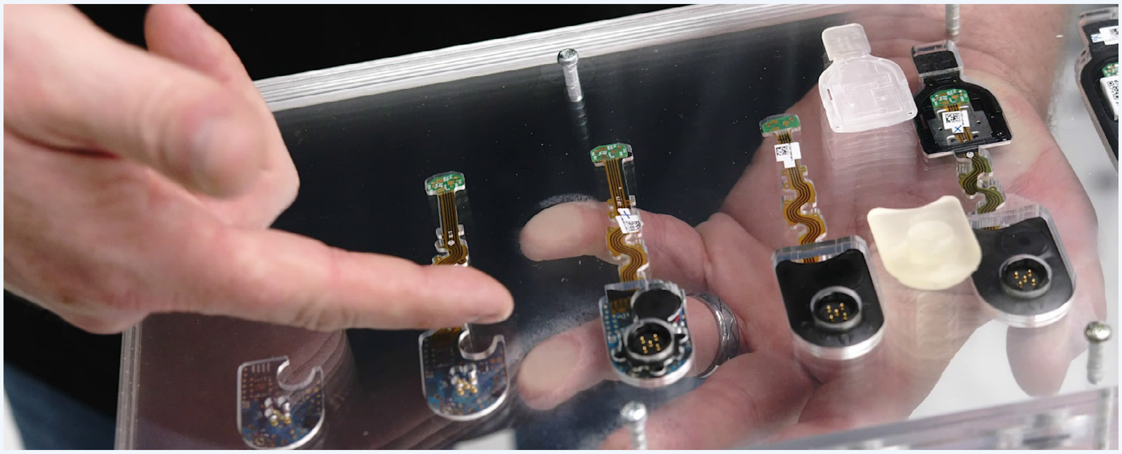
3D printed parts are commonly used as stand-ins, sometimes called surrogate parts, that can be used to accurately simulate part geometries, steps in the assembly process, or other characteristics of a product during manufacturing operations. Two typical benefits of surrogate parts are the enabling of assembly or manufacturing lines to get up and running without waiting on long-lead time components, and saving costly subassemblies from getting damaged or compromised as a process is dialed in.

3D printed tooling is also helpful for determining whether a specific part geometry will work in a final material without investing in hard tooling, which typically comes with higher costs and longer lead time. 3D printed injection molds, vacuum forming patterns, wax injection molds, and investment casting patterns are easily fabricated with SLA resins, allowing engineers to conduct low risk testing of new parts and products by creating quick-turn tooling or patterns in house.

CASE STUDY: Google ATAP

Google's Advanced Technology and Projects (ATAP) group used 3D printed surrogate parts to accelerate their manufacturing validation and save roughly $100,000 in wasted assemblies.

Dialing in the molding process for a new wearable device was complicated due to a multiple shot molding process, and the fine features of the electronics themselves. The team at ATAP realized that rather than molding around fully populated circuit boards, they could substitute 3D printed parts that matched the circuit board geometry. This meant that they could use low cost 3D prints during the dialing in process rather than expensive PCBs, giving their manufacturing team more room to perfect the molding process without the risk of throwing away tens of thousands of dollars worth of assembled electronics.



Google's ATAP division used Formlabs High Temp Resin to create surrogate parts for dialing in a new overmolding process, saving them over $100,000.

Direct Printing End-Use Parts

Using 3D printing as a final manufacturing process for parts is among the newest and quickest growing application areas. Advances in material science, production scheduling software, and automation are making 3D printing more cost competitive with traditional manufacturing, especially for high mix, low volume products. It is also ideal for products that require a high degree of customization, or products where the unique geometries made possible through 3D printing have performance benefits.

CASE STUDY: New Balance

New Balance uses Low Force Stereolithography 3D printing to create intricate, functional lattice structures for their shoe line that would be impossible to produce with traditional manufacturing. 3D printing allows New Balance to take advantage of unique materials and geometries to reduce weight, simplify assembly, and shorten their supply chain. The first product in their 3D printed line, the Triple Cell 990S, sold out within 24 hours of launch.

The unique lattice structures that can be produced with 3D printing allows New Balance to create finely tuned geometries that balance stiffness, structure, and support with far more flexibility than a traditionally molded midsole.

Conclusion

While this is far from an exhaustive documentation of SLA 3D printing use cases, it demonstrates how dramatic changes in material science and printed part performance translates to a notable expansion in the use of 3D printing for manufacturing workflows. Already, for manufacturers large and small, 3D printing is a ‘must have’ tool in the toolbox, offering greater flexibility and lower cost than many traditional fabrication processes.