



“The technology produces a robust and highly repeatable process.”

Elliott Schulte / Bell Helicopter Textron Inc.

#### CASE STUDY

# Developing Flight-Ready Production Hardware with Laser Sintering

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As a leading developer of military and commercial helicopters, Bell Helicopter Textron Inc. continually pushes the limits of what can be achieved in the world of vertical lift. It looks to set the pace for the industry and provide exceptional value for its customers with superior design. To date, Bell Helicopter has manufactured and sold more than 35,000 helicopters worldwide.

The engineering-driven company has a rich history of looking forward to advance its aircrafts and requires manufacturing solutions that allows them to fulfill design goals. When it came to the creation of functional hardware for its helicopters, Bell explored additive manufacturing, a process already known to yield reliable results for prototypes. Now Bell was hoping to put the technology to the test and see if 3D printing would meet its strict guidelines for functional production parts.

Having worked with Stratasys Direct Manufacturing previously, Bell Helicopter reached out to them again – this time for their expertise in 3D printing customized production components.

## THE CHALLENGE

Bell needed components for its helicopters quickly and with a repeatable process at a competitive cost with conventional manufacturing. Using designs that took advantage of part consolidation, the engineers at Bell planned to save time and money by eliminating some additional assembly, decreasing or eliminating rework and reducing component weight.

The parts identified for production were ducting parts for its environmental control systems (ECS) and other components throughout the aircraft. This included defog duct nozzles which prevent the front windshield from clouding up and disturbing the pilot's visibility. These pieces were complex in design, with multiple geometrical intricacies and internal features – an endeavor perfect for additive manufacturing. Traditional manufacturing processes were too cumbersome to fulfill Bell's design for the complicated parts.

From the material used to the finished product's performance, the parts had to meet aerospace quality standards and Bell's rigorous testing processes. With the helicopter's unique weight requirements, the final pieces would have to be lightweight. Bell was also looking to maximize any available economic advantage throughout the entire process.



Parts and tensile bars mid-build in Laser Sintering machine



Defog duct nozzles being excavated from powder

## THE SOLUTION

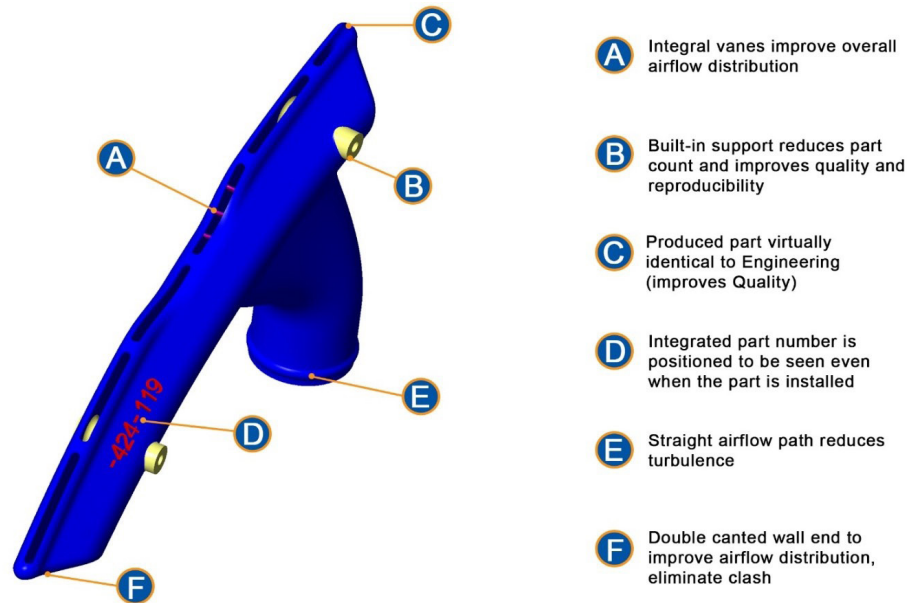
To fulfill these strict requirements, Stratasys Direct Manufacturing recommended Laser Sintering technology to build components which would meet Bell's project needs. Laser Sintering (LS) creates tough and geometrically intricate components using a powerful CO<sup>2</sup> laser to melt powdered Nylons.

Working with an optical delivery system that utilizes mirrors to direct the lasers, this process requires significant expertise and effort to produce robust products repeatedly. Stratasys Direct Manufacturing maintains stringent process controls and procedures to maintain the LS machines and reliably deliver reiterative pieces.

As parts are built layer by layer in an LS machine, they remain encased in powder, removing the need for support structures. This allows an engineer to design for functionality, without having to consider breakaway structures or other support configurations. Furthermore, laser sintering could achieve lower wall thicknesses than injection molding even though the materials have similar specific gravity values.

Another key design advantage in additive manufacturing is the ease of part consolidation enabling engineers to incorporate multiple component designs into single structures for one build. For example, designs that employ part consolidation can help lessen the weight of the final build piece by eliminating hardware used to join parts – a significant benefit for an aerospace company like Bell.

Additive manufacturing, and specifically LS in this case, can produce complex features, undercuts and internal features effectively. Leveraging the design freedom of additive manufacturing, including part-consolidation, engineers were able to design for maximum functionality as seen in the defog duct nozzle below, designed for Bell's 412 helicopter:



Stratasys Direct Manufacturing executed assessments for Bell to confirm the capability of Laser Sintering for the project with tests for powder degradation (the analysis of powder chemistry post build), correct heat distribution during the build, dimensional accuracy, repeatability, and the overall quality and performance of the parts. Bell confirmed the results, paving the way for production of the needed components.

LS parts have significantly less post-processing needs due to the lack of break-away support structures. When the build is finished, the LS pieces are removed from excess powder; what typically emerges is a functional part ready for cosmetic finishing.

*“Tool-less manufacturing means you don’t face certain limitations and upfront costs.”*

“In addition to the design advantages, there are significant manufacturing benefits to LS technology. Tool-less manufacturing means you don’t face certain limitations and upfront costs. And if you need to change something, you can build new revisions simply by changing the CAD file. There is no need to update or produce new molds and very little wasted time or money,” said Greg Reynolds, vice president of additive manufacturing at Stratasys Direct Manufacturing.

Complex components built with traditional manufacturing could require long lead times to develop and manufacture each piece. With LS technology, the more complicated the part, the greater the advantage for the end user.

## THE RESULTS

In addition to verifying Stratasys Direct Manufacturing's AS9100 and ISO 9001 certifications, Bell also completed manufacturing site and production equipment qualifications per Bell Process Specifications. Preliminary inspections of the Belton, Texas manufacturing site and its laser sintering machines concluded, and Stratasys Direct Manufacturing proceeded with production of Bell's aircraft components.

Speaking of the additive manufacturing process, Elliott Schulte, Engineer III at Bell Helicopter, said "The technology produces a robust and highly repeatable process. We often discovered that the production cost per piece is reduced compared to conventional manufacturing methods when producibility is a factor. As an example, the defog nozzle was able to take advantage of laser sintering as a higher yield process and do so with increased geometric complexity that resulted in improved performance."

Perfectly suited to Bell's requirements, Stratasys Direct Manufacturing performed inspections, including nitrogen leak rate checks and monitoring mixing of powders, and tracked the thermal process during the build. Mechanical properties of builds were inspected to confirm each time that LS produced parts adhering to specification and product quality requirements.

**"The technology produces a robust and highly repeatable process."**

"After every build, we test for tensile and flexural properties," said Grant Shirley, quality manager at Stratasys Direct Manufacturing, "By following these checks, Stratasys Direct Manufacturing was able to execute the process with excellent repeatability and quality."

By using LS to manufacture the defog duct nozzles for the 412 program, Bell realized a weight savings of 13% and a lead time compression of 75%. Employing design consolidation reduced the part count by three part numbers. Bell Helicopter estimated a cost avoidance of \$120K because of the elimination of conventional tooling and rework.

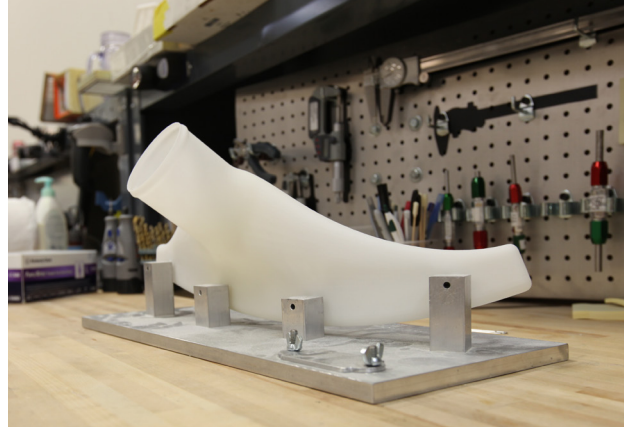
Overall, for Bell's 429 helicopter program, there was a 24% part-count reduction when designs were converted to laser sintering, with six materials reduced and rework eliminated. The most crucial savings for the 429 program was in weight. Bell measured an overall weight reduction of 2/3 lb. for every 1 lb. of laser sintered weight.



Four ECS ducting parts manufactured for Bell Helicopter.

“3D printing these parts delivered an immediate weight savings benefit,” said Dinesh Sharma, the Sr. Technical Specialist working on the ducting transition. “Additionally, the lower part count translated into cost savings on the administrative side including inspection, purchasing, and product support. Subsequent change incorporation is also much faster and cheaper given that there is no permanent tooling to be maintained or modified.”

Bell’s results exemplify an important certainty for the aerospace industry: embracing additive manufacturing for even the smallest components on an aircraft reaps undeniable rewards.



Check fixture for defog duct nozzle

“3D printing these parts delivered an immediate weight savings benefit.”

Bell Helicopter is continuing to explore innovative designs for additively manufactured parts throughout its aircrafts’ systems. The engineers who worked with Stratasys Direct Manufacturing for development of environmental control systems are now helping other engineers at Bell understand the function and materials involved in additive manufacturing.

Bell is on the cutting-edge of aerospace companies looking to harness the benefits and technology of 3D printing with its own R&D Rapid Prototyping Lab which includes Laser Sintering, Fused Deposition Modeling™ and Stereolithography machines. By seeking to further streamline manufacturing processes, Bell is using additive manufacturing to transform how it designs and manufactures its helicopter components.

Delivered quickly, with a repeatable process and at a competitive cost per piece, 3D printing was the perfect solution for the helicopters’ ECS ducting. With the advantage of the design freedom of Laser Sintering, Stratasys Direct Manufacturing was able to deliver the complex designs quickly and at Bell Helicopter’s industry-leading quality standards.



Before & after part-consolidation of defog duct nozzle



Defog duct nozzles installed in a Bell 429 helicopter

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