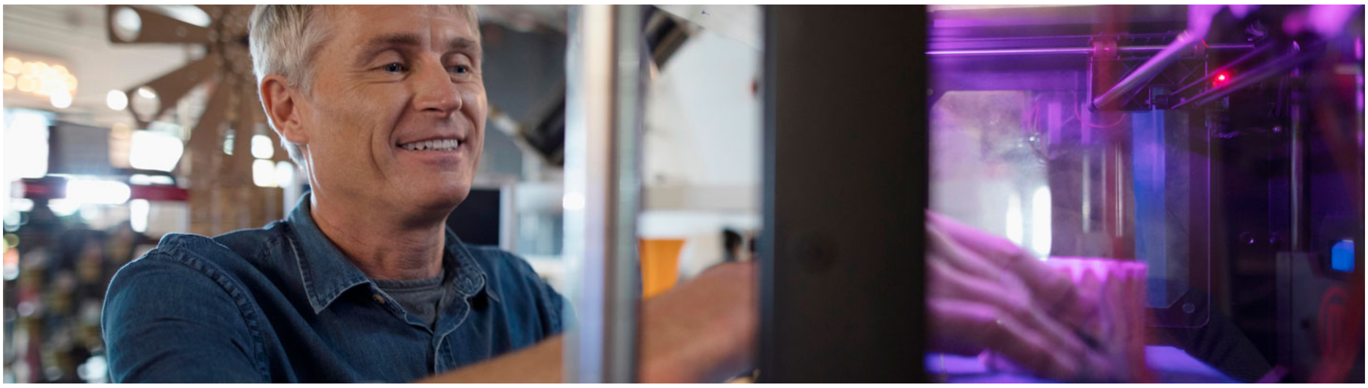

Machining

The Amazing Evolution of 3D Printing in Aerospace and Defense

Don Sears | Aug 06, 2019

They may not be critical-for-flight hardware yet, but 3D-printed parts for commercial and military aircraft and spacecraft are making it easier to reduce weight and material costs. Translation: There is ROI here for very specific use cases—and functional gain from the savings being put to good use.

Additive manufacturing has a bright future. But how bright will it be for the aerospace and defense industry? We explore how 3D-printed parts are making an impact today—and look at some of the limitations.

We spoke with engineering experts at 3D Systems and 3DDirections to find out where additive manufacturing and 3D printing in aerospace and defense is heading. But first, let's look at the evolution of the industry in this vibrant vertical.

The History of 3D Printing and Additive Parts for Aerospace and Defense

The aerospace and defense industry, especially the U.S. military, was an early adopter of 3D-printed parts, but mostly for testing and simulation because the fire and toxicity ratings of plastics were not up to par with metals for flight—both in space and above the clouds.

These test parts were mostly used in drones and satellites, explains Bryan Newbrite, an application engineer at *3D Systems*. Between 2008 to 2013, additive-made plastics like Bluestone were used in testing for things such as wind tunnels and in ducting parts, but ceramic resins were also used for simulations.

These use cases were good for mimicking the flow of wind. These parts were never used with humans. Before this era, in the mid-1990s, some 3D parts were used for quick castings.

Things began to change around 2007 to 2013.

"The biggest change in the aerospace sector was actually the development of flame-retardant selective laser sintering," Newbrite says. "It's one of the few things that you began to find in use in commercial aviation … Basically it took nylon 12 or nylon 11 and added in flame retardants so that it would pass flame testing."

This was significant because it meant the material could hold some heat without catching fire—and could put itself out quickly without giving off toxic fumes.

It was first used in satellites. The main reason? Return on investment.

“It costs $40,000 to $50,000 per kilogram to put a satellite in geostationary,” Newbrite says. “So if you can design a structural bracket or an internal member of a satellite and shave a few kilograms, well then the actual added cost of having to build it out of additive is more than taken care of.”

> ## Putting the ROI from Additive 3D Printing to Great Use
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> As with many improvements in the aerospace and defense industry, the strength-to-weight ratio is critical. Manufacturers are always working on research and engineering development to experiment with materials that weigh less but maintain strength for space or high-altitude flight.
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> When you shave off a few kilograms of a very expensive raw material for one with an additive part, the ROI makes a huge difference. But that savings isn’t exactly pocketed. It is put to use.
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> “No manufacturer actually cashes that money saved,” explains Bryan Newbrite of 3D Systems. “Instead, they add more battery power or they add more functionality. When you’re going to launch a satellite, you’re pretty much going to want to hit that weight within a few grams, because you’re already paying for that space [on the satellite].”
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> A company like 3D Systems helps a satellite maker redesign parts, such as structural brackets and other hardware that removes some of the weight. Functionally, it means the satellites are designed to have a longer life with more redundancy. More battery power means that spacecraft can potentially go farther in space for longer

A Pivotal Moment in the History of 3D Printing in Aerospace: GE’s LEAP Engine Fuel Nozzle

One of the most notable additive parts made for commercial aviation was a ***3D-printed fuel nozzle*** by GE, for the LEAP engine. It is a shining example of how the efforts of research and development come to fruition—and garner a lot of attention for innovation.

“The way GE was successful in this project was that they just had to use brute force to make it happen, which meant that they built thousands and thousands of these nozzles in order to be able to qualify them as viable parts that can be printed,” explains ***Chris Barrett***, president and founder of 3DDirections, an additive manufacturing consultant and mechanical engineering expert.

Barrett works for Universal Technology Corporation as a research scientist and is a Ph.D. candidate at Youngstown State University in Ohio.

“The way they had to make it before is basically tons of layers of foil of different types squished together,” Barrett says. “And that was the only way they could get the complexity that it needed. For the 3D version, it used the same layered approach, but picture doing it manually."

According to ***GE***, the 3D-printed nozzles are "five times more durable than the previous model" and the additive approach "allowed engineers to use a simpler design that reduced the number of brazes and welds from 25 to just five."

A Common 3D Printing and Additive Manufacturing Theme: The Reduction of Parts, Steps or Weight

Both Barrett and Newbrite point out that most 3D-printed parts for aerospace and defense are not flight-critical today. Despite GE's foray with fuel nozzles, high-volume production is an issue.

"Over time I'm sure that the additive technologies and approaches will catch up," Newbrite says. "But cost-wise, you really don't see a ton of it right now in production. The large commercial aircraft have become very efficient. Really, most use cases right now are heavily focused in military, drones, unmanned aircraft and satellites, where weight really matters."

Traditional manufacturing methods with advanced and precision CNC machines will continue to dominate the industry because they remain the most cost-effective.

"It's usually 10 to 100 times the cost of traditional," Barrett says. "So it needs to show a 10 to 100 times improvement as a part at the end of the day."

Yet there are some applications in use today, and many others that are being evaluated. The large commercial and defense OEMs including Boeing, Airbus, Honeywell, GE and Lockheed Martin are investing heavily in additive manufacturing research.

Barrett points to another R&D project from GE that attempted to print most of the parts of a plane engine—an advanced turboprop, or ATP—and was successful using titanium superalloys.

"GE took an engine that had been made from 855 parts and got it down to about 12," Barrett says. "They were able to reduce the weight of the engine by 100 pounds and boost fuel efficiency by 20 percent."

The weight reduction also allowed a 10 percent bump in power over its predecessor. This engine is planned to roll into production for Textron Aviation's Cessna Denali plane.

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3D Printing for Aerospace and Defense: MRO and Spare Parts

One of the more interesting use cases for 3D printing is the making of spare parts for legacy aircraft, such as those found on C-130s and B-52s. The aircraft are older but are still in use for transporting cargo and troops—and their parts are becoming harder and harder to replace, explains Barrett.

The problem? Planes may be grounded for extended periods—sometimes for several years because of a lack of spares. Some of these aircraft date back 50 years, and companies don't make parts for them anymore—or they have gone out of business. Companies willing to make spares may take years to complete them.

"When we started researching this, we found that some of these parts, because they've sat in the plane and have been beat around for so many decades, have stretched and warped as the plane has stretched and warped," Barrett says. "So each part is a little bit different, because the 90-degree turn right now is no longer 90 degrees, it might be 85 degrees. Well, I can't make one cast mold that accounts for all these differences. So it makes a perfect case for 3D printing."

Companies like 3D Systems and others can make custom parts for each plane by bringing 3D scanners onto a plane, creating digital files and printing each part tailored to fit the shape and geometry of that part in its current condition.

This legacy spares project involves a number of public and private organizations through ***an initiative*** called the Maturation of Advanced Manufacturing for Low-Cost Sustainment, or MAMLS, which is funded by the Air Force Research Laboratory.

One manufacturer that has made inroads with C-130 planes is Metro Aerospace, a company featured on Better MRO at the 2018 International Manufacturing Technology Show. Metro Aerospace has been delivering microvane parts to the military. Microvanes are made of a lightweight, noncorrosive, durable polymer composite that includes glass and nylon bead.

Read all about the challenges and production success of Metro Aerospace in the article "How to Take a 3D-Printed Part to Market in Aerospace."

Are you impressed by a 3D-printed turboprop engine? Talk to your peers in the metalworking forum. [registration required]

