Constant Improvement

Jeff DeGrange on the state of additive manufacturing for aerospace

By Morgon Mae Schultz, Stratasys Inc.


Jeff DeGrange

Stratasys Vice President Jeff DeGrange, formerly of Boeing, is a longtime advocate for additive manufacturing (AM) for the aerospace industry. He led Boeing's advanced-manufacturing technology team, applying forward-thinking technologies across defense, commercial-aircraft and space products. DeGrange was the first chairman of Boeing's Direct Manufacturing Research Center in Germany, which studies emerging additive-manufacturing (sometimes called 3D printing) technology for the engineering and manufacturing community.

DeGrange was part of the initial ASTM International F42 committee to set additive-manufacturing standards and serves on the Society of Manufacturing Engineering Rapid Tooling and Additive Manufacturing committee. He's also an advisor to the Chicago Museum of Science and Industry, helping introduce youth to engineering through a fabrication lab, where he says kids can learn that manufacturing is fun, creative and digital.

Jeff, how is additive manufacturing changing the aerospace industry?

Historically, in functional prototypes — form, fit and function. An aerospace company, years ago, used additive manufacturing to build a full-scale nose landing gear for a commercial aircraft to evaluate the design for clearance issues with the primary structure.

With computing power becoming faster and cheaper, and over the last five years with a broader suite of materials becoming available, additive manufacturing has expanded into fabrication and assembly tooling. Tooling is really catching on at U.S. military depots, particularly with the Navy and Marine fleet readiness centers. They're using it for making one-off repairs, small-volume sets of skins or repair parts for damaged vehicles.

With the use of the material ULTEM 9085, which is a flame-, smoke- and toxicity-rated material designed decades ago by GE Plastic for commercial aircraft use, we're starting to see acceptance by the commercial aviation industry for end-use parts, typically low-volume manufacturing but a mix of many products. For example, in the business-jet community, they may build 500 jets for 50 different customers. Each of those 50 customers is going to say, "I want my cockpit to look like this. I want my cabin to look like this." And AM end-use parts give them the economies of scale. That flexibility to meet the needs of this wide product mix is really catching on within the general aviation community.

Another huge application is ground support equipment. All kinds of tools and equipment

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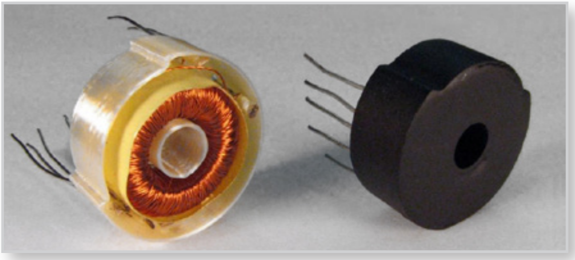
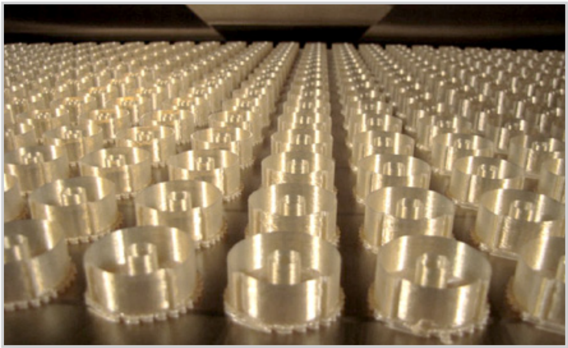
support the aircraft when it's on the ground, and AM can create that equipment, as wells as training aids. When new flight mechanics and technicians get trained on various systems, they'll use physical mockups rather than high-dollar components. Sheppard Air Force Base does this. NASA is another organization that uses training aids because they often have very complex systems.

Can you tell me about some private-sector aerospace companies using AM?
There's a German company called Stukerjurgen Aerospace. It's a tier-one supplier to Airbus, Boeing, Bombardier and Embraer for many products in the cabin, lavatory and cockpit. And they are really learning how to apply AM for many components.





Kelly Manufacturing makes toroid housings using ULTEM 9085 on an additive manufacturing system. The method requires no tooling and offers the tight tolerance needed for this device.

Another is Custom Control Concepts in Seattle. They're using AM for in-flight entertainment and cabin-management control — managing the temperature and the air flow in the cabin, and customizing the interior of a business jet or other aircraft.

It seems as AM advances, it becomes viable for uses later in the product-development cycle — tooling and finished goods. Why, and why now?
Twenty years ago, the technology was just a baby. Nobody knew about it except a small group of people, and that was more in product development. The machines were much smaller. Materials were very limited. In the early days, it was truly more of a prototyping machine than a production machine. As time went on, machines got bigger and faster and cheaper, and more materials were available. The Internet helped spread the word. And now that door is open. We haven't really begun to flood into all the areas in which we could use it, which makes it a really fun and exciting industry to be in.

Regarding tooling, it takes a significant amount of time and cost with traditional methods. And when the final tool is made, in many cases it doesn't meet the ultimate requirements. So now you've got all this cost sunk into it and you have to go back and rework or even redesign it. A good example of this is forming metal around a tool to give it its shape. Engineers have to allow for a certain amount of springback when the stress releases, and that's not an exact science. Close, but not exact. With AM, you can iterate after the fact with far less cost and time penalty.

And we're seeing a side benefit versus metal tools: It's a lot lighter — 50 percent lighter compared with aluminum tooling. It's easier to use by the people on the shop floor, more ergonomic.

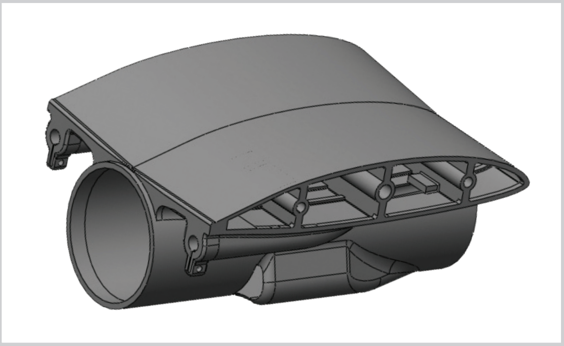
What about production parts?
Producing finished goods for the cabin with AM is really taking off because of ULTEM 9085. It could be air grates, panel covers, and various other interior parts. And behind all those skins and in the belly of an airplane, heating and cooling ducts, power-distribution panels and all kinds of clips and brackets in special configurations for a given manufacturer.

And as the materials continue to get stronger and additional materials come out, we can start looking at secondary structures. That means ULTEM parts could start bearing some loads. AM also allows us the potential to start looking toward putting carbon or glass in it to get reinforced thermoplastics, which could mean a broader array of metal replacements in the future.

A lot of manufacturers are using AM to make unmanned aerial systems (UASs). Why is this?
UASs are gaining capabilities. And with these complex systems, rapid design iteration becomes important. Additive manufacturing has the CAD/CAM capability to do that. You can produce complex shapes that are difficult or impossible with conventional technologies.

This applies beyond UASs: During the build you can design in pockets, then drop in electronics — a strain gauge or a pressure sensor — or nuts and bolts or bushings embedded into the build. And then, in the future, integrate with other technologies. We will soon have smart parts coming out of the machines.

What value do advanced manufacturing capabilities hold for the defense industry?
New technologies are always critical to improve product capabilities, particularly for defense. That could mean making a UAS lighter so it can fly farther or carry more payload. How can you go farther with less fuel? Technology is required to do that, whether it's lighter-weight materials or shapes and designs that you can't do with conventional approaches.



SelectTech Geospatial engineers perfected this drone through many iterations. Test flights were executed with functional prototypes made on an additive manufacturing system.

You often hear the phrase "arms race" in other industries, like, "It's a computer-processing arms race." But here, it's literally an arms race.
That's right, because our enemy is finding ways to counter that technology, so there's always constant iteration going on. AM can help with this because it can compress that design-build cycle.

In the defense industry, often you've got 10 pounds of stuff here and you need to stick it in a five-pound area. Now you can come up with all these crazy shapes so you can do that. Packaging for every millimeter of space is permitted with AM because you produce those designs cost-effectively.

The technology is also very scalable. If you've got a factory that has 10 machines and all of a sudden you need to make twice as many, you can add machines quickly. You can plug and play to ramp up capacity, or do it over a distributed network.

Private-sector budgets are tight and militaries are facing spending cuts. Why would aerospace organizations invest in additive manufacturing?
The technology's very versatile. You could use it one week to do engineering prototypes and the next week produce a variety of manufacturing tools, then make finished goods. And retrofit tooling, and spare parts for support of in-service vehicles — the versatility is just tremendous.

And, you know, when you start talking about the business case, and what the program managers and business owners will be asking about, it's not uncommon to see a 60 to 70-percent reduction in lead time. And costs are usually trimmed significantly — anywhere from 25 to 70 percent. The world we live in is that you've got to do it faster and cheaper.

What it really comes down to is the output. Stratasys' technology, Fused Depostion Modeling (FDM), uses engineering thermoplastics. And the properties are really good. Temperature resistance, chemical and UV resistance, and environmental resistance. And they don't absorb moisture. Those properties give FDM an advantage over many of the other additive-manufacturing systems.

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