3D PRINTING PROMISES TO REVOLUTIONIZE DEFENSE, AEROSPACE INDUSTRIES

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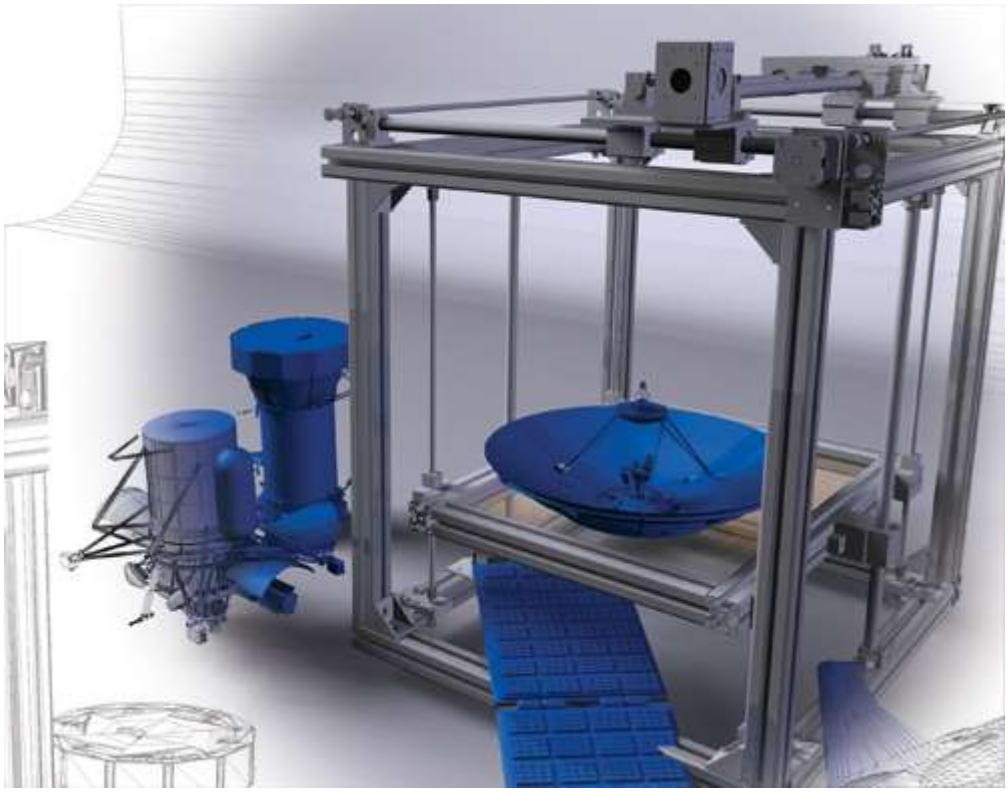


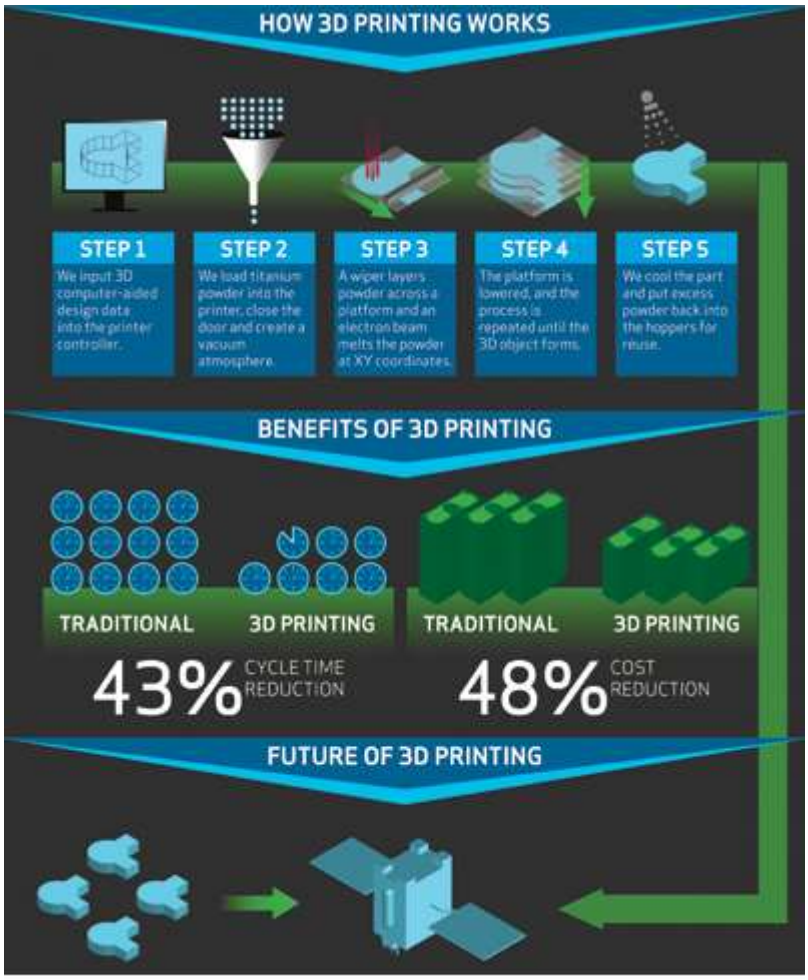
New manufacturing processes, such as 3D printing, have gained worldwide attention for creating everything from entire houses to guns. While used for many novel purposes, the defense and aerospace industry is eyeing it as a way to cut costs and improve efficiency.

Three-D printing shakes up the traditional process of manufacturing — which takes raw materials and subtracts from it by whittling or drilling — by adding layers of a substance, often a polymer or metal, to create an object. The method, which is also known as additive manufacturing, only requires a user to download a blueprint to the printer. Because the process uses fewer materials, it can save companies money as well as allow them to create parts on the fly, according to industry technologists.

As printers become smaller and less expensive, the defense and aerospace industry stand to glean major cost savings from the technology. Using more advanced printers and metal-based substances, companies are looking to manufacture hard-to-make items, such as brackets and tools for multi-million dollar programs ranging from satellites to jet fighters, according to experts interviewed.

Printers can now make advanced parts for aircraft engines, said Hugh Evans, vice president of corporate development and ventures for 3D Systems, a Rock Hill, S.C.-based additive manufacturing company.

The aerospace industry is adopting additive manufacturing "at a very fast rate because you can 3D print aircraft engine parts and take weight out," Evans said at a Council on Foreign Relations panel on the topic in Washington, D.C.



A Lockheed Martin graphic explains the benefits of 3D printing

General Electric and Rolls-Royce recently announced they will begin using 3D printing to manufacture certain engine components.

General Electric has been funneling millions of dollars into 3D printing technology for years, said Steve Rengers, the lead of General Electric Aviation's research and development group.

In 2012, the company acquired Morris Technologies and its sister company Rapid Quality Manufacturing in Cincinnati, Ohio. Both companies specialized in additive manufacturing.

Since then, General Electric has been working to incorporate 3D printing into its products, Rengers told National Defense. It turned the Cincinnati facilities into its Additive Development Center, where engineers test out applications for the technology, he said.

"We are the research arm of GE as far as additive goes," said Rengers.

Additive manufacturing will be a component of General Electric's forthcoming LEAP engine. The engine — which is being built by CFM International, a joint venture between General Electric and Snecma, a French aerospace company — will include 19 3D-printed fuel nozzles each, Rengers said.

To make the fuel nozzle without additive manufacturing, multiple parts would have to be separately created and fused together, he said.

"In our case … 20 pieces would have to be made and then joined … to get this complex assembly," said Rengers. With additive manufacturing, "we are able to do that in one shot on a machine, so it makes things a lot easier. There is a lot less risk involved with that assembly."

The engines are slated to enter production in 2016 and are being marketed toward the commercial aviation industry.

The pieces are created using a type of 3D printing known as direct metal laser sintering, which uses super metal alloys to manufacture objects layer by layer.

"Because you're doing something one layer at a time, you can essentially build in elaborate passages into your product," said Rengers. "It opens up design freedoms. ... You're able to produce designs and components that you could never do with traditional manufacturing."

EOS 3D Printer

Besides fuel nozzles, General Electric is also looking at printing about a dozen components and using 3D printed parts in its other engines, Rengers said. He would not disclose which parts the company is considering.

Three-D printing is revolutionizing the aerospace industry, Rengers said. "We believe it is a … game changer, and it will allow engines to run more efficiently in the future. … We envision performance benefits, cost savings and fuel savings."

Today, the 3D printing market is worth $3 billion, Evans said. He predicted it would increase tenfold to $30 billion over the next decade.

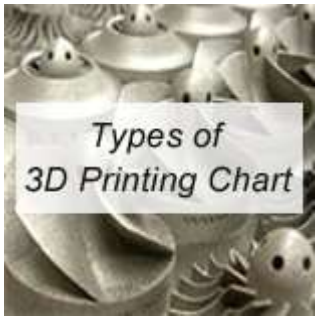
Additive manufacturing started in the late 1980s but has only gained worldwide notoriety in the past several years, said Rob Gorham, deputy director for technology development at America Makes, a Youngstown, Ohio-based additive manufacturing institute.

Low-cost 3D printers have brought the manufacturing process into the limelight as hobbyists latched on, he said. There is more access to the technology than ever, he said.

"It's a fact that the very large capital requirements that were required to really take advantage of these processes … have come down so much that basically anyone can operate these processes," he said. "The ability to manufacture goods and services is not on the very large, multi-billion dollar corporation level anymore. It has actually entered into the homes of individuals."

Now more defense and aerospace companies are embracing the technology as well, though they use more advanced and expensive systems that can cost $500,000 to $1 million each, he said. The evolution of 3D printing has gone through four steps, Gorham said. In the early days, it was used for making models of prototypes. Then it allowed parts to be tested in systems, which is called "functional prototyping." After that, it was used to make complex tools. Now it can make functional parts, he said.

As time goes on, the prices of even advanced printers will continue to drop, he said, which will fuel more innovation in the defense and aerospace market.



There are numerous processes that fall underneath the additive manufacturing umbrella, Gorham said. Some techniques include direct laser metal sintering, electron beam melting and fused deposition modeling, all of which have differing finishes, durability and size capabilities.

America Makes started as the National Additive Manufacturing Innovation Institute in 2012. It was created after President Barack Obama called for an emerging manufacturing technology institute to be created that same year. The public-private institute is led by the National Center for Defense Manufacturing and Machining, which won an initial $30 million award in federal funding to kick-start the center.

America Makes now works to help industry and government advance 3D printing, said Gorham. It is currently working on 22 separate projects and engaging with dozens of different companies.

As the technology progresses, the future is bright for additive manufacturing, he said. "We want to continue to mature because we know it's a viable alternative to [traditional] manufacturing processes. We fully expect it to further integrate itself into … design solutions," Gorham said.

Lockheed Martin Corp. is embracing additive manufacturing, said Steve Betza, corporate director of hardware engineering and advanced manufacturing at the company.

"We are aggressively deploying additive manufacturing … across all of our business areas," said Betza. "We do see great innovation with purpose and an entire family of applications."

Juno spacecraft

Lockheed is currently using 3D-printed parts for satellite manufacturing. Printed parts are already onboard the solar-powered Juno spacecraft heading to Jupiter. The craft was launched in 2011, and is expected to arrive in July 2016.

There are a dozen 3D-printed brackets on Juno, said Suraj Rawal, a fellow and principal research scientist at Lockheed. The brackets are made out of titanium alloy and were made through an additive manufacturing process known as electron beam melting, he said.

Lockheed plans to use 3D printing in other spacecraft programs, including the Orion Multi-Purpose Crew Vehicle, said Rawal. They already have begun making prototypes of certain parts, including a forward bay cover that is 7-feet in diameter, he said.

The forward bay cover is one of the largest parts ever printed in the aerospace industry, Rawal said. While just a prototype for now, it is currently under consideration for use in production.

The Orion is envisioned as a vehicle to transport humans into deep space, where they can explore asteroids, the moon and Mars.

F-35 Joint Strike Fighter

Additive manufacturing is ideal for this type of experimental manufacturing, Betza said.

"It's a very safe, productive environment to be doing prototyping of components," he said.

Lockheed is also considering using printed parts on the F-35 Joint Strike Fighter, said Betza.

Some small components made out of titanium could be put in the wings or tail of future F-35s, he said. The parts are currently under evaluation, he noted.

Lockheed is also considering using 3D printing for other programs, said Rawal.

"We continue to invest in more and more parts using additive manufacturing," he said. "The parts are already moving as we speak."

The Boeing Co. has also integrated 3D printing into some of its aircraft, company officials said.

"We see additive manufacturing for metals as a key discriminator for not only giving ourselves a competitive advantage relative to our competitors, but also the savings cost," said David Dietrich, the company's research and technology lead engineer for additive manufacturing in metals.

Polymer-based air ducts created through additive manufacturing are already on board the F/A-18 Super Hornet, said Michael Hayes, Boeing's research and technology lead engineer for additive manufacturing in polymers.

"We've been doing it for the Super Hornet since the beginning," he said.

The company is also using 3D printing to make satellite brackets, said Dietrich. He declined to specify which spacecraft.

A 3D-printed bracket onboard the Juno

"You need a lot of design functionality for a really tight little space in a satellite where every square inch and every pound in a satellite costs an enormous amount," he said.

Additive manufacturing allows engineers to create complex brackets that are able to fit inside these small spaces. Instrumentation, such as sensors, can then be added, he said.

Boeing's 3D printed brackets were first demonstrated three years ago and continue to be developed, he noted.

Additive manufacturing has also made a big splash in the area of tooling, Dietrich said. Using 3D printing, engineers in assembly factories can print out customized tools that help with the manufacturing of complex items, he said.

F/A-18 Super Hornet

One of the best features of 3D printing is the ability to experiment, said Hayes.

Additive manufacturing suits small-scale, rapid production innovation.

"If you combine those two attributes … you come into this kind of fertile ground," he said. "It's a great area for new technologies."

In the future, entire unmanned aerial vehicles could be printed, he said. "[UAVs] are a great component. It's a great platform, and there is no doubt about it. It's a … low production volume, you're not cranking out 10,000 of them," Hayes said.

But don't expect entire 3D printed airplanes any time soon.

"It's a very interesting technology. It's very fun. It's a big step. … [But] it doesn't replace traditional manufacturing. It's just another tool in our toolbox to use and allow us to do different things that we haven't been able to do in the past," Hayes said. "We're still going to make airplanes the same way for quite a long time until things really, really advance."

One roadblock for a potential 3D-printed airplane is glass for the windshield. Additive manufacturing cannot make that right now, Dietrich said.

Cost is also a factor. Additive manufacturing is useful when it comes to complex items, but it is not always the most efficient or inexpensive way to create an item, he said.

"It's a more customizable way to make things, not necessarily a cheaper way to make things," said Dietrich.

Hayes said: "It's really hard to beat the cost of aluminum sheet metal. That's your competition. … It's a pretty low price."

Besides aerospace, other transportation industries will soon adopt 3D printing, Evans said. Printed engine parts for cars, trains and helicopters are around the corner.

"Anything that moves in transportation is going to have a 3D printing input because you can take weight out of the design," Evans said. "Weight is gold in transportation fuel savings."

By Yasmin Tadjdeh

Photo Credit: Scott Rekdal, Lockheed Martin, General Electric, Boeing

Chart Credit: America Makes

READER COMMENTS

Arcam's partnerships in research and production with GE, NASA, ORNL (Oak Ridge), Disanto, etc are beginning to pay off. Industrial additive manufacturing is certainly an exciting field to keep an eye on. *Mark on 02/22/2014 at 12:23*

Sciaky (Chicago, IL) is one of the few metal additive manufacturing companies with experience and a ton of potential muscle in the aerospace industry: http://www.sciaky.com/additive_manufacturing.html *Louis on 02/19/2014 at 17:14*

Defence aerospace technology was already so advanced and especially in the US. D printing is going to put it the step forward. Today, 3D printers can even print a house! Check this out: http://nusteel.com.au/3d-printing/ *Adrien on 02/16/2014 at 20:*