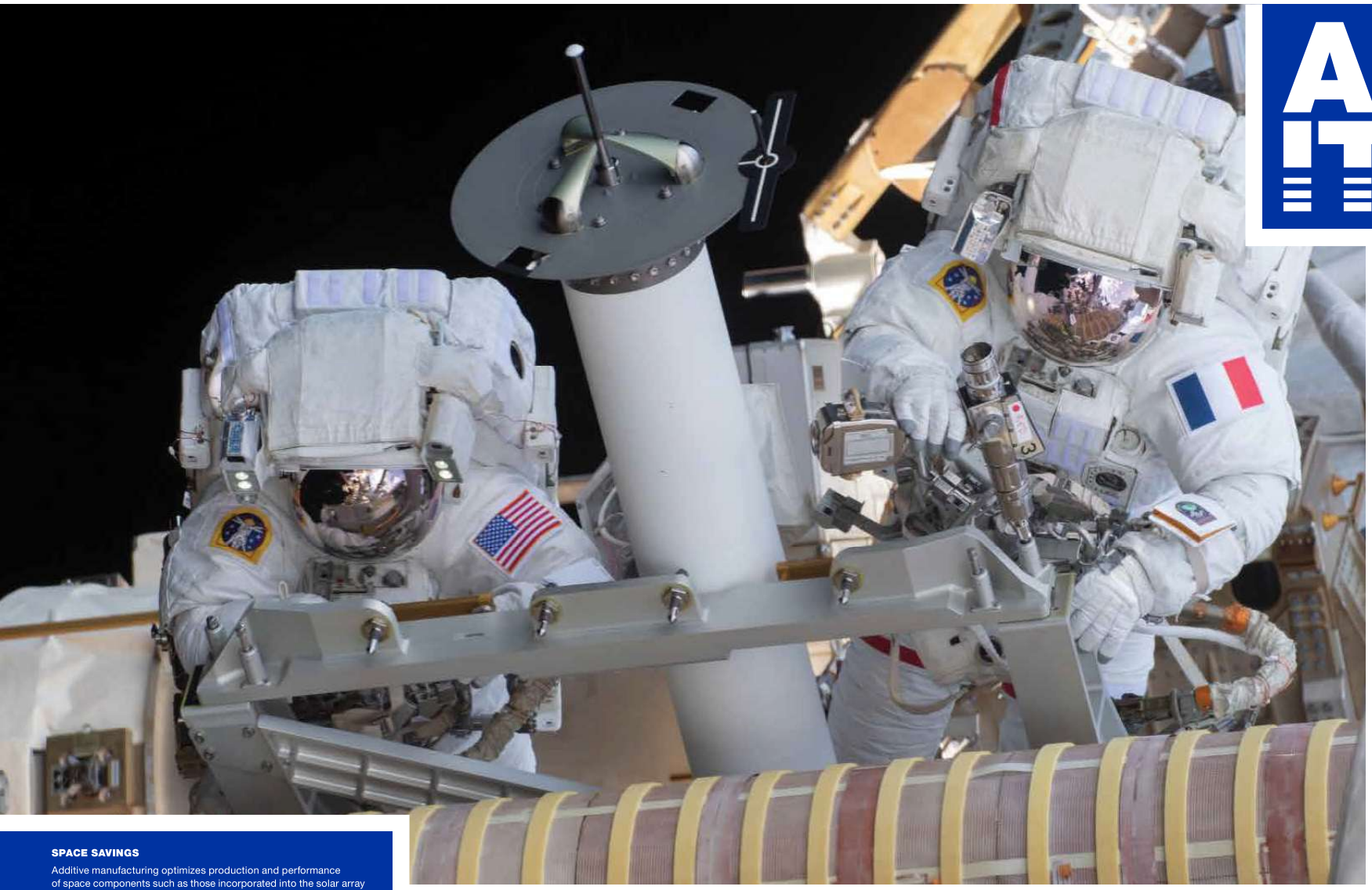
ADD IT UP



SPACE SAVINGS

Additive manufacturing optimizes production and performance of space components such as those incorporated into the solar array carrier pallet for the International Space Station.

PHOTO: NASA

Discover how additive manufacturing will shape aerospace — and already has

PHOTO: BOEING

Dr. Melissa Orme is vice president of Boeing Additive Manufacturing. She is responsible for growing and scaling additive manufacturing (AM) capabilities and helping to rapidly expand understanding of the unique features that AM can bring to Boeing factories and production lines. An early AM pioneer, Orme is listed as an inventor on 15 U.S. patents.

In the following Q&A with Innovation Quarterly, Orme outlines how Boeing has been at the forefront of AM for aerospace for decades and continues to be a pathfinder for future applications.

IQ: Let's start at the start. Why is it called additive manufacturing?

MO: It's called additive manufacturing because you build a part and a material, one layer at a time. You're adding material, microlayer by microlayer, as opposed to subtractive manufacturing, which [includes many] traditional processes, where you take a block of material and you cut it away until you have your final part.

So you're adding material layer by layer. It could be polymer. It could be a metal. There are many different modalities, but that's basically what we're doing. And that allows you then, when you add it layer by layer, cross section by cross section, it allows you to have really complicated geometries that you're not able to have traditionally. It enables you to have some really complex internal features that improve performance of the part that you can't have traditionally. And it allows you to make things in really odd shapes so that you can fill in some odd cavities of a spacecraft or aircraft to become more efficient and streamlined.

IQ: Is there a difference between additive manufacturing and 3D printing?

MO: Additive manufacturing is 3D printing. But 3D printing has sort of come to be regarded as more hobbyist. People can buy 3D printers for polymer on Amazon. And they put them in their garages. And they can make all kinds of neat things for their home, for example. That's 3D printing.

Additive manufacturing, by definition, is also 3D printing. But when you think of manufacturing and additive manufacturing, we're really referring to, especially for aerospace, flight hardware. We're producing quality parts that can go onto vehicles. They're certified for flight. And so there's a whole quality process that goes behind that, more than just 3D printing.

IQ: So we're definitely not doing that in our garages.

MO: No, we're not.

PROOF OF CONCEPT
This additively manufactured prototype of an extreme environment heat exchanger features complex geometry that cannot be produced by conventional fabrication methods.
PHOTO: BOEING

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AIRPLANE APPLICATION
This 787 manifold used to be three separate pieces assembled together. Additive manufacturing allows the manifold to be produced as a single part.
PHOTO: BOEING

INTRICATE SHAPE
This upper Y bracket is one of three additively manufactured parts on the deployable ion engine mount for a recently launched satellite. Additive manufacturing optimized the design — printing material only where needed — resulting in an overall 28-pound (12.7-kilogram) reduction.
PHOTO: BOEING

IQ: Why is additive manufacturing ideal for aerospace?

MO: It's ideal for aerospace really because carrying weights into space is expensive. We're continuously trying to make our planes, our satellites, our helicopters lighter in weight. And because additive manufacturing has this capability [through topology optimization], it's really a mathematical methodology, where you place material only where it's needed in the part to support the loads and you remove it from all other parts.

Sustainability in 3D

Additive manufacturing (AM) is changing the way Boeing designs and builds aerospace products, allowing the company to use less raw materials, create less waste and improve fuel efficiency.

Significantly less material is required to create a part with additive methods, reducing the carbon footprint at the front end. As for the end product, AM enables highly innovative designs that add functionality, reduce weight and volume, and consolidate many parts into one, further adding to Boeing's sustainability goals.

DR. MELISSA ORME, VICE PRESIDENT, BOEING ADDITIVE MANUFACTURING

COMMAND PERFORMANCE

The command horn antenna consolidated numerous components into a single monolithic design.

PHOTO: BOEING

And so now you have a highly optimized part. It's incredibly lighter ... and is really beneficial to the aircraft by reducing this weight.

Also in aerospace and in space, oftentimes these platforms are highly customized. The production rates lend themselves to additive manufacturing. If we're talking about satellites, usually there's not a whole lot of vehicles. So spooling up tooling for that wouldn't be very efficient. And we can customize each one. So it really makes a lot of sense.

And then for airplanes, it's really a matter of removing weight and making the airplane lighter ... and more streamlined. And that not only makes the airplane more efficient, but it really adds to our sustainability goals, right? Because it's using less fuel to get it where it needs to be. It's a positive sustainability driver.

IQ: So it sounds like Boeing is doing a lot in this space. What is most exciting to you? What is the one thing you tell family and friends? "We're doing this with additive manufacturing"?

MO: Oh, actually, it's a really long list. We're doing a lot. ... I'm not sure everybody knows that Boeing has additive-manufactured products onto our platforms for 30 years. And we have 70,000 parts right now, and a lot of those are polymer, and a lot of those are different modalities, also metal. We have actually a robust history of additive manufacturing. And it's almost a well-known secret that I'm trying to open up and advertise a little more.

But the most recent things have really come out of satellites. We've created a new 3D-printed satellite, which is a product that transforms how satellites of this size are manufactured. And we are consolidating many, many parts into one for other satellite applications like Wideband Global SATCOM.

Those are really exciting — well, there are two more. For MQ-25, we have a heat exchanger, and the reason why that's exciting is because it's [on] an airplane with a different loading environment.

And another one which is really important to me — we have a Chinook helicopter searchlight which is in a harsh environment, really high fatigue. And it's in flight right now. We have 15 of these on helicopters in duty.

EXCHANGE OF IDEAS

Complex internal geometries are achievable using additive manufacturing. Such is the case for the phased array antenna heat exchanger (below) created for the MQ-25 (above).

PHOTOS: (ABOVE) KEVIN FLYNN/BOEING; (BELOW) BOEING

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LIGHTER LIGHT

Boeing designed, manufactured, tested, qualified and delivered several metal, additively manufactured searchlights currently in service on CH-47 Chinook helicopters. The high-intensity lights represent the company's most advanced metal additive manufacturing application to date for use in a harsh environment.

PHOTO: BOEING

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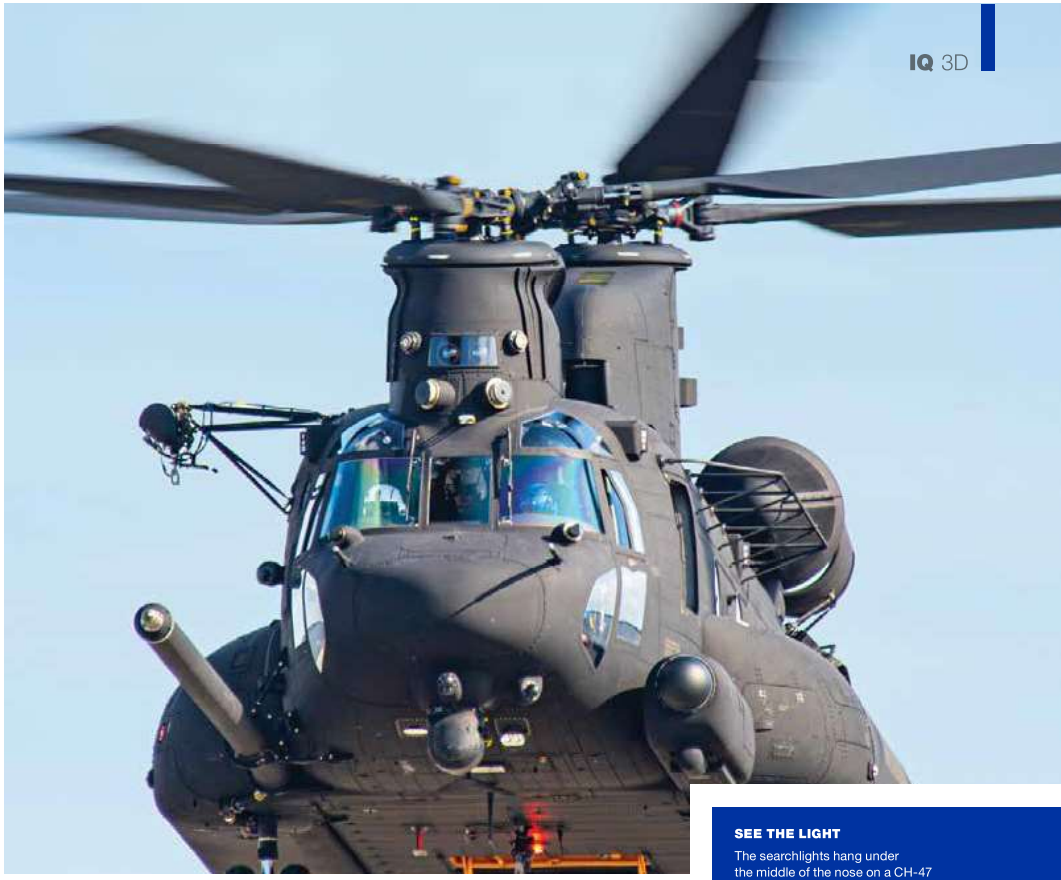
IQ: If we dig into your resume, we can see from your background that you could have gone anywhere. Why did you choose Boeing? What drew you to the company?

MO: I began in academia. I was a tenured professor. And then I went into small business. And everything that I've always done with respect to my career has been a move that really challenges me, that pushes me out of my comfort zone. I really think that you just need to keep growing and learning as an Individual. At least that's how I feel about myself. And I had never worked in a large corporation before. I knew there would be challenges I wasn't even aware of. And I wanted to face that.



SEE THE LIGHT

The searchlights hang under the middle of the nose on a CH-47 Chinook helicopter.

PHOTO: BOEING

And so that's, that's one answer, but there's another slightly sweeter answer. And that is that my father worked at Boeing during the SST, the Supersonic Transport. It was a really good period in my family's life. And I've always had a bit of nostalgia about that. I lost my father when he was quite young. And I was young. I like to think that he would be proud, knowing that I'm here. **IQ**

We have a Chinook helicopter searchlight which is in a harsh environment, really high fatigue. And it's in flight right now. We have 15 of these on helicopters in duty.

SCAN CAM HERE, BOOST YOUR IQ!

Audio: Hear the entire 3D conversation.

HERE TOO FOR MORE IQ!

Video: See additive manufacturing happen.