2024 Q3 | Volume 8 | Issue 29

IQ INNOVATION QUARTERLY

INNOVATION. INSIGHT. INSIDE AEROSPACE.

787 Dreamliner Difference

Calculating the contributions of composites

PLUS: Learn the Language
Engineers demo a new way for manned and unmanned aircraft to talk

FIBER FUSELAGE
Karin Anderson watches a machine layer miles of microscopic carbon fiber tape to form a 787 Dreamliner fuselage.

BOEING

INNOVATION QUARTERLY

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Cover Story: The 787 Dreamliner Difference
Technical Fellows calculate the contributions of composites.

04

12

Calling Currawong
Communications system gets the message through.

44

Material Machine
Custom machine adds vertical production to vertical lift.

19 | Tech That Connects
Chief Technology Officer explains how technologies enhance air travel and advance aerospace innovation.

26 | Something Old, Something New
737 fuselage becomes new training ground for Boeing electricians.

32 | Clear as Day
Daytime satellite tracking technology offers around-the-clock views of orbiting satellites.

34 | From 'What If' to 'Watch This'
Engineers demo a new way for manned and unmanned aircraft to talk, and mum is not the word.

50 | TopShot: Trailing Contrails
Boeing and NASA take a close look at contrails.

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goboeing.co/iq

IQ IS ...
Innovation Quarterly invites readers to go inside the future of aerospace with the people who make it happen.

PHOTO: BOEING

Intelligent Innovation

Technology drives discovery

Applying innovation in aerospace leads to the creation of amazing products that change the world. While we focus on today's needs and priorities, we're also watching the horizon, continuously exploring new designs, materials, methods, technologies and processes to support our global customers.

Our people enable bold explorations, inventions and discoveries. An increasingly sophisticated array of computing, networking, data storage and analytic capabilities also creates new possibilities. Every day, Boeing teams rely on these powerful technologies to innovate and, more importantly, improve aerospace safety and quality.

For example, artificial intelligence (AI) opens up endless opportunities to support first-pass quality and build stability in our production system. Making drawings easier for mechanics to read and simplifying installation instructions are just a few ways AI and other technologies are driving improvements in the next generations of products and services.

This issue of Innovation Quarterly offers a look at some technologies that are making a difference in aerospace engineering today:

- Discoveries in composite materials for the 787 Dreamliner.
- Breakthroughs in battlefield communications.
- Developments in human-machine interfaces between the F/A-18 and the MQ-25.
- Groundbreaking manufacturing automation for the H-47 Chinook.

May each story inspire you to find solutions for today and move you to seek even more exciting opportunities for the years ahead. **IQ**

Susan Doniz
Chief Information and Data Analytics Officer
Senior Vice President,
Information Technology & Data Analytics

The 787 Dreamliner Difference

Technical Fellows calculate the contributions of composites

BY KAITLIN STANSELL, BOEING WRITER

Twenty years ago, Boeing engineers predicted the use of composite materials in the design of the 787 Dreamliner would improve efficiency, durability, and even passenger comfort. Seeing the results after more than a decade in service, Boeing Technical Fellows count the promises made as promises kept.

SPOOLS OF INNOVATION

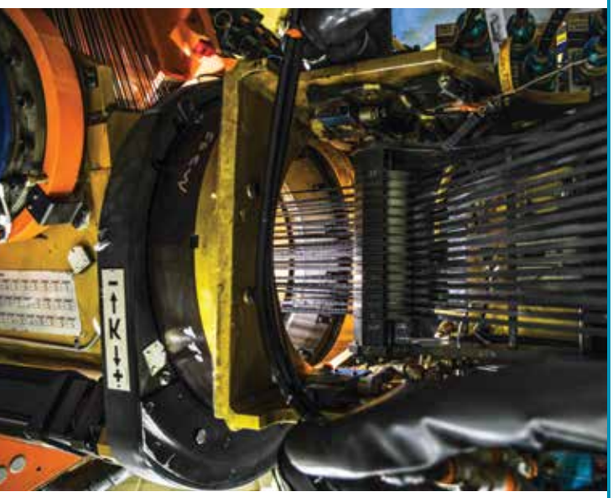
Boeing Technical Fellow Karin Anderson looks into the carbon fiber tape dispensing system of an automated fiber placement machine at Boeing South Carolina.

PHOTO: KAITLIN STANSELL/BOEING

FIBER FEEDER

Carbon fiber tape feeds through an automated fiber placement machine to layup precise patterns and layers around the circumference of the 787 aftbody fuselage section.

PHOTO: JOSHUA DRAKE/BOEING



> “We have learned that composite structures can result in an unprecedented combination of efficient and robust structure design.”
>
> **PATRICK ENJUTO,**
> **BOEING TECHNICAL FELLOW**

Dreamliner by design

Boeing’s introduction of the 787 Dreamliner in 2004 signaled a significant departure from traditional commercial airplane manufacturing. With an airframe comprised of 50% carbon fiber reinforced plastic and other composites, the 787 entered history as the Boeing commercial airplane with the most extensive use of composite materials. Designers believed composites would offer numerous advantages over conventional aluminum designs, and they have since proven the advantages of composites are real.

“We have learned that composite structures can result in an unprecedented combination of efficient and robust structure design,” said Boeing Technical Fellow Patrick Enjuto. “Some of our earlier 787s are currently undergoing their first major maintenance inspections with excellent results. Operators are going in all the way to the bones of the airframe to get an extensive look at how the airplane is performing in service.”

Extensive testing has proven the durability of the Dreamliner’s composite airframe, Enjuto said. To date, about 700 in-service airplanes have undergone routine maintenance checks, revealing zero evidence of composite airframe fatigue.

On average, each 787 operates about 600 flights per year.

Thanks to the material properties of composites and their use on the 787 fuselage structure, passengers enjoy the view from the largest windows available for commercial jets. Beyond the open-cabin aesthetic, Enjuto said composite materials offer more options in cabin design, contributing to lower cabin altitude pressurization and increased cabin humidity.

According to 787 Chief Engineer John Murphy, composite materials reduce airplane weight and provide aerodynamic benefits, contributing to the 787 Dreamliner being up to 25% more fuel-efficient than previous-generation airplanes. Since entering service in 2011, the 787 has avoided more than 170 billion pounds (77 billion kilograms) of carbon emissions.

BREAKING THE MOLD

Composite materials are more shapable and flexible than most metals, enabling engineers to design airplane wings that are as beautiful as they are efficient.

PHOTO: BOEING

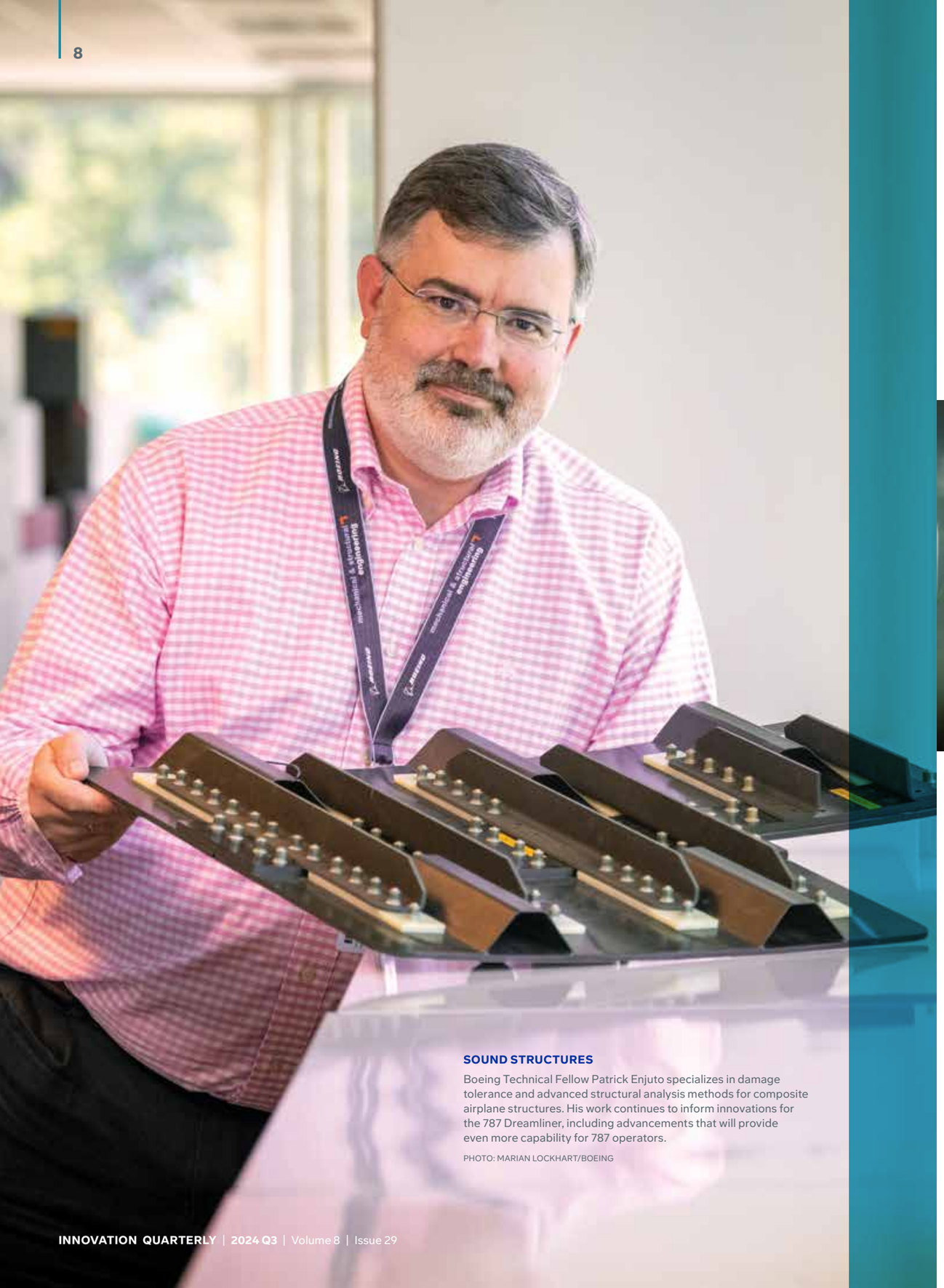
787
The first decade by the numbers

Opened more than **410** new nonstop routes

Flew nearly half of the **15** longest routes in operation today

Made more than **4.4M** flights

Served over **900M** passengers



SOUND STRUCTURES

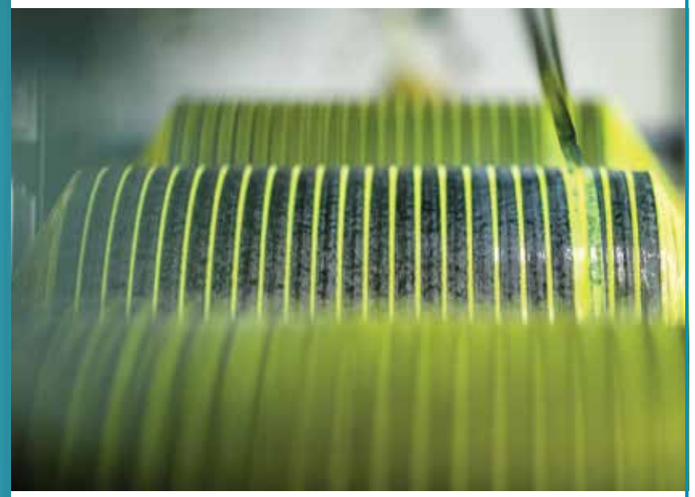
Boeing Technical Fellow Patrick Enjuto specializes in damage tolerance and advanced structural analysis methods for composite airplane structures. His work continues to inform innovations for the 787 Dreamliner, including advancements that will provide even more capability for 787 operators.

PHOTO: MARIAN LOCKHART/BOEING

FREEZER TO FLIGHT

Spools of carbon fiber material that will construct the aftbody sections of the 787 Dreamliner fuselage remain in a freezer until ready to use.

PHOTO: JOSHUA DRAKE/BOEING



> “One of the disadvantages to metals is they cannot be formed easily. Composites allow design engineers to take a more artistic, inspired-by-nature approach. You can soften the wing to look more like a bird’s wing for example, improving performance with a more aerodynamic and even elegant design.”
>
> **KARIN ANDERSON, BOEING TECHNICAL FELLOW**

End-design in mind

Composites have transformed airplane design, offering several advantages over traditional materials:

- **High strength-to-weight ratio**
  Composites are often stronger than steel yet lighter than aluminum, making them ideal for airplane construction.
- **Corrosion resistance**
  Unlike metals, composites do not corrode, enhancing durability, especially in harsh environments.
- **Fatigue resistance**
  Composites can endure cyclic stresses without degradation, improving the life span of the airplane.
- **Design flexibility**
  Composites can be molded into complex shapes, allowing for more innovative and efficient structures.

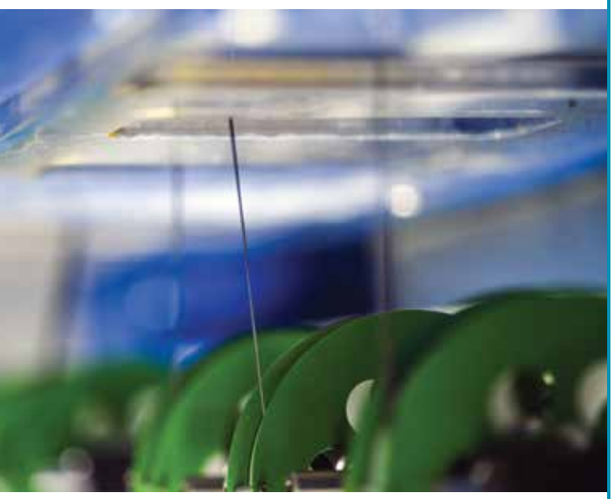
“One of the disadvantages to metals is they cannot be formed easily. Composites allow design engineers to take a more artistic, inspired-by-nature approach. You can soften the wing to look more like a bird’s wing for example, improving performance with a more aerodynamic and even elegant design,” said Boeing Technical Fellow Karin Anderson.

Boeing’s pioneering use of composites in the 787 Dreamliner set a precedent that continues to influence future products, most notably the 777X, which features an extraordinary composite wing design.

FINE-TUNED FORMS

Carbon fiber tape that is used in the production of the 787 Dreamliner fuselage is approximately the thickness of two strands of hair.

PHOTO: JOSHUA DRAKE/BOEING



> “With a clear engineering focus on improving producibility, we’re documenting our best design practices to capture the lessons learned and understand the reasons for the approaches taken for using composites on the 787, the 777X wing and other products.”
>
> **KARIN ANDERSON, BOEING TECHNICAL FELLOW**

Flying forward

“The 787 Dreamliner has proven composite materials are durable, strong and efficient,” said Enjuto. “There will still be a place for metals in airplane structures, but composites are here to stay. Future developments will show more benefits in manufacturing processes, fuel efficiency and structural design advancements.”

The 787 has demonstrated the efficiency and quality of several advanced manufacturing techniques, including the use of automated fiber placement machines in fabricating fuselage sections. But there’s still more to learn to optimize producibility of composite parts.

“With a clear engineering focus on improving producibility, we’re documenting our best design practices to capture the lessons learned and understand the reasons for the approaches taken for using composites on the 787, the 777X wing and other products,” Anderson said.

“Additionally, there is a lot of work being done to improve Boeing’s analysis tools, including investments in smart testing, artificial intelligence and machine learning. We want to refine requirements for Boeing’s future products, and we know composites will be part of that future.” **IQ**

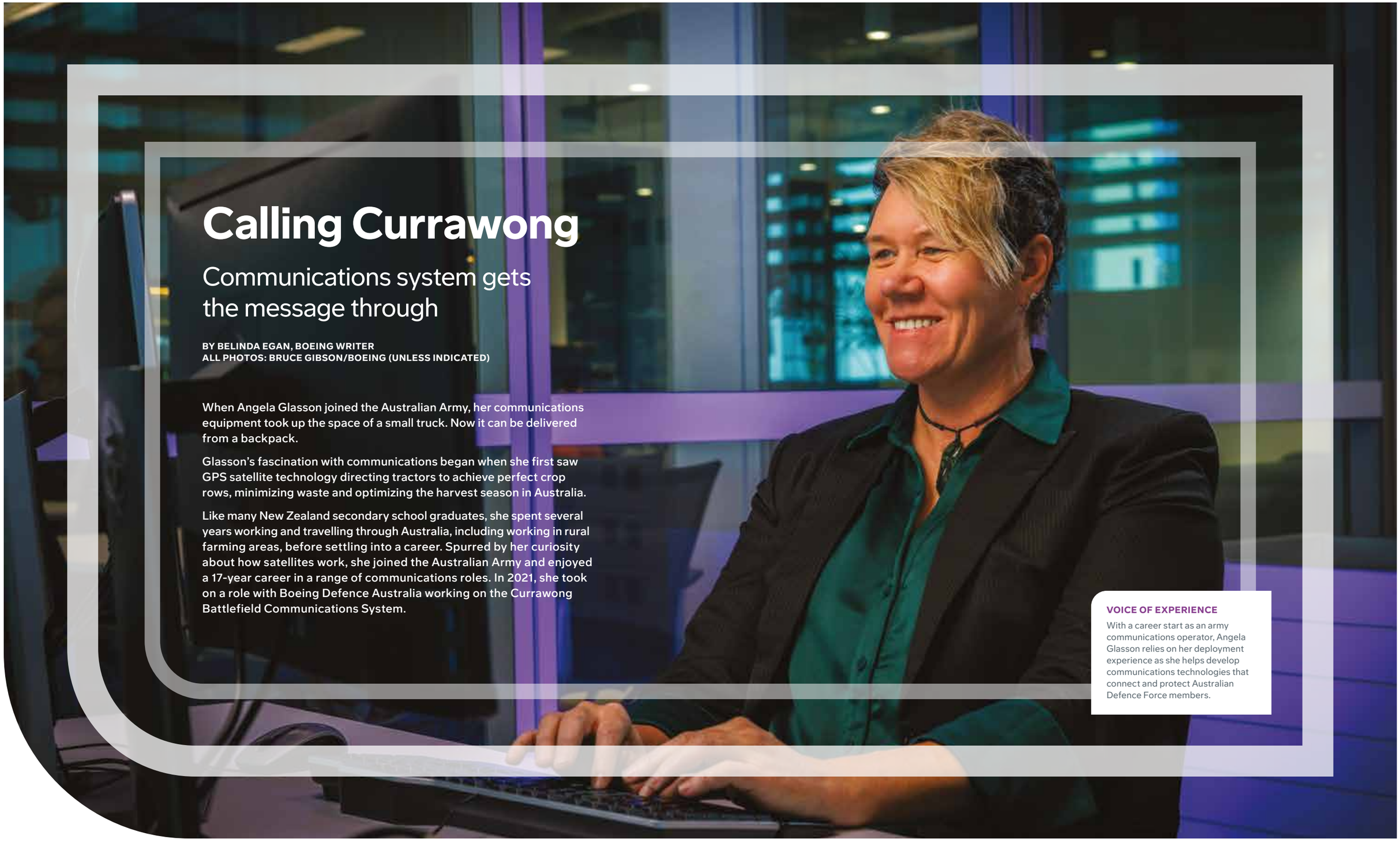
INSIDE IQ
Watch a machine layer carbon fiber tape to build the aftbody sections of the 787 Dreamliner fuselage.

IQR

MEASURE IN MILES

If the carbon fibers used in the 787 Dreamliner were stretched across the United States, they would span about 2,200 miles (3,540 kilometers) — from North Charleston, South Carolina, to Los Angeles.

PHOTO: JOSHUA DRAKE/BOEING



Calling Currawong

Communications system gets the message through

BY BELINDA EGAN, BOEING WRITER
ALL PHOTOS: BRUCE GIBSON/BOEING (UNLESS INDICATED)

When Angela Glasson joined the Australian Army, her communications equipment took up the space of a small truck. Now it can be delivered from a backpack.

Glasson's fascination with communications began when she first saw GPS satellite technology directing tractors to achieve perfect crop rows, minimizing waste and optimizing the harvest season in Australia.

Like many New Zealand secondary school graduates, she spent several years working and travelling through Australia, including working in rural farming areas, before settling into a career. Spurred by her curiosity about how satellites work, she joined the Australian Army and enjoyed a 17-year career in a range of communications roles. In 2021, she took on a role with Boeing Defence Australia working on the Currawong Battlefield Communications System.

VOICE OF EXPERIENCE

With a career start as an army communications operator, Angela Glasson relies on her deployment experience as she helps develop communications technologies that connect and protect Australian Defence Force members.

SIGNATURE SLOUCH

In her first official army photo, Glasson wears the signature headdress of the Australian Army, commonly referred to as the slouch hat. Glasson deployed throughout the Asia-Pacific region during 17 years in the army.

PHOTO: COURTESY OF ANGELA GLASSON

> “Reliable, consistent and secure communication is critical to commanders in deployed environments. It enables them to understand and respond to what is happening in their surroundings and accelerates response times to allow for effective high-level planning and execution of tasks in the battlespace.”
>
> **ANGELA GLASSON, BOEING PROJECT MANAGER**

Field revelations

“During my career in the Australian Army, I deployed to multiple countries in the Asia-Pacific region, including Timor-Leste, the Solomon Islands and Papua New Guinea,” Glasson said. “Our mission was to restore stability in these countries following periods of civil unrest.”

Glasson’s role was to enable tactical and strategic communications through a secure network to support Joint Task Force operations.

“Reliable, consistent and secure communication is critical to commanders in deployed environments. It enables them to understand and respond to what is happening in their surroundings and accelerates response times to allow for effective high-level planning and execution of tasks in the battlespace,” said Glasson. “My duties ranged from setting up and maintaining large-scale tactical and strategic communications to small deployable teams.”

On deployment, Glasson worked in remote locations, staying on the move, assembling and disassembling bulky equipment.

“At times we were traversing difficult or hilly terrain, and my equipment to support just one individual could weigh up to 50 kilograms. We had a real need for field equipment that was portable, lightweight and intuitive.”

Today, Glasson proudly works on a deployable communications system that protects and connects Australian Defence Force members anywhere in the world.

“When I first saw what Boeing was doing with Currawong, I immediately understood its value for the end user,” Glasson said.

Soon after, she left the army and took a role with Boeing.

“I could see that the Boeing team was thinking out of the box. They had addressed many of the restrictions that had limited me when I was in the field and opened up new forms of communication,” Glasson said.

OFF ROAD

As the Australian Army deploys in remote and isolated environments, they can rely on the durable Currawong system. At the Army Testing Grounds in Monegeetta, north of Melbourne, Australia, this mobile headquarters gives commanders everything they need to stay connected while on the move.

MISSION TO TEST

Boeing engineer Luke Biddle, right, helps prepare a radio networking device for field testing at Gallipoli Barracks, Enoggera, Queensland.

Unlikely connections

One example Glasson gives is the Radio Interface System, which allows multiple radios, not dependent on type, to connect to each other.

“It sounds simple, but before this system was implemented, all radios in a network had to be like for like, which put a burden on unit resources,” she said. “The Currawong RIS revolutionized field communications, allowing users to connect to the radio network via a number of different types of hardware, including desktop phones — an entirely new way of communicating.”

From radios to satellites to secure public internet network access and mobile vehicle-mounted headquarters, the Currawong system adapts to mission requirements. Operators can scale it up or down to support small units of five users or major task forces of up to 500 users.

“As Boeing developed the technology, we operated in a continual agile development cycle,” Glasson said. “We worked fast, tested fast and learned fast in a continuous feedback loop.”

DIRECT CONTACT

Australian Defence Force members stay in touch by connecting up to six radios through the Currawong system.

> “The Currawong RIS revolutionized field communications, allowing users to connect to the radio network via a number of different types of hardware, including desktop phones — an entirely new way of communicating.”
>
> **ANGELA GLASSON, BOEING PROJECT MANAGER**

MESSAGE BEARER

The mission system manager, housed in the small laptop device, chooses the best transmission option, such as satellite, cable or antenna, and switches seamlessly between methods so operators never lose their connection. The case on which it rests provides power and supports a range of plug-ins, including networking, routing, video, voice and data services.

CALL IN THE WILD

The call of a pied currawong rings loud and clear, reaching throughout remote regions of the Australian outback. Aptly named, the Currawong Battlefield Communications System connects the Australian Defence Force anywhere in the world.

IMAGE: BARRY CALLISTER PHOTOGRAPHY/GETTY IMAGES

> “The system was delivered on time and on budget, and much of its success came from working directly with army operators to test concepts, gain real-time feedback, make improvements and drive innovation.”
>
> **ANGELA GLASSON, BOEING PROJECT MANAGER**

Work, test, learn, repeat

Glasson coordinated a unique approach to testing demonstrations, called Mission System Integration Test Events (MSITEs).

“In the early days of development, these events enabled army operators to test new hardware and software prototypes firsthand,” she said. “As we progressed, our engineers used the MSITEs to present various systems and their capabilities to our army and industry stakeholders.

“The system was delivered on time and on budget, and much of its success came from working directly with army operators to test concepts, gain real-time feedback, make improvements and drive innovation.”

Glasson now works on projects that incorporate Currawong components into other military platforms and programs. Boeing Defence Australia has adapted the system for use by the Australian navy and air force and is working to anticipate future battlespace communications needs and exploring how to support its Defence Force customer.

“It means a lot to me to be part of developing such an exceptional capability, knowing that those who come after me are benefitting from a contemporary communications system that is fit for purpose and is constantly evolving to keep them safe and connected,” Glasson said. **IQ**

BOOST YOUR IQ
Count the ways Currawong connects deployed forces.

IQR

Tech That Connects

CTO explains how technologies enhance air travel and advance aerospace innovation

Across product design, development, delivery and sustainment, technology drives aerospace innovation.

Chief Technology Officer Todd Citron shares the strategies and priorities behind the big ideas at Boeing, and why each is important for the future.

TALKING TECH

Boeing Chief Technology Officer Todd Citron leads Boeing’s research efforts around the world.

PHOTO: BOEING

IQ&A

IQ What are the greatest technical challenges facing the aerospace industry?

TC

Challenges are really opportunities, and it's exciting to be in a period where there are so many opportunities.

The current industry environment is reflected in Boeing's technology focus areas: sustainable, producible, autonomous and digital. All are essential to address current industry needs — such as the rapid resurgence in air travel following the pandemic — with safe, high-quality products and services.

Regarding sustainability, we're evolving technologies to help the industry achieve net-zero carbon emissions by 2050:

- First, we're driving more efficient operations. One example of this is our work demonstrating trajectory-based operations for aircraft routing, which will decrease emissions by about 10% and increase airport capacity.
- Second, we're developing alternatives in renewable energy. Boeing airplanes will be compatible with 100% sustainable aviation fuel by 2030. Unblended, or "neat," SAF, which is totally free of fossil fuels, can reduce life cycle carbon emissions up to 84% when compared to conventional jet fuel and offers the industry's largest potential to reduce carbon emissions over the next 30 years in all aviation segments. While we're helping to improve the SAF supply, we're also studying a range of alternate energy technologies, including hydrogen, for the longer term.
- And third, we're maturing technologies that improve efficiency and reduce waste. The most visible is the X-66 Sustainable Flight Demonstrator. Its extra-long, thin wings show promise of improving aerodynamic efficiency. When combined with expected improvements in propulsion, structures and systems, we believe the transonic truss-braced wing configuration could reduce emissions by up to 30% compared with today's best-in-class aircraft.

The current industry environment is reflected in Boeing's technology focus areas: sustainable, producible, autonomous and digital.

All are essential to address current industry needs — such as the rapid resurgence in air travel following the pandemic — with safe, high-quality products and services.

ELECTRIC EVALUATION

At Wisk, leaders Brian Yutko, left, and Jim Tighe, right, discuss the airframe of Wisk's 6th Generation air taxi with Boeing engineering director Ramy Mourad and Citron. Before flight testing and production, engineering teams evaluate the structure components and materials for safety and quality.

PHOTO: WISK

IQ What about the other technology focus areas?

TC

We're advancing producibility by employing autonomy in our factories. For example, cameras and robotics automate manufacturing inspections and yield more consistent results. Teams use technology to analyze manufacturing data, while machine learning analyzes data from fabrication tools. These technologies spot degradation much earlier, resulting in tighter manufacturing tolerances that enhance safety and quality.

Globally, we're developing material and automation technologies to improve production quality and increase rate production.

Underpinning it all, model-based engineering is enabling rapid iteration and enhancing engineering quality on multiple platforms, including the MQ-25 Stingray and the T-7A Red Hawk advanced trainer.

And we're on the verge of safe, certified autonomous flight with Wisk, a Boeing subsidiary in Mountain View, California. Numerous technologies are driving the design of the vehicle, known as an electric vertical takeoff and landing air taxi.

URBAN SKY

Wisk teams simulate how eVTOL vehicle operators manage air taxi traffic in large metropolitan areas.

PHOTO: WISK

IQ&A

IQ How does Boeing determine its technical priorities?

TC

Technology only adds value when there's a need. We must determine the probability any technology will transition to a product, service or business operation.

First, we objectively define the need. For example, "advanced structures" have no defined use, but structural technology that improves strength to weight by 50% is a well-defined need.

Next, we identify the date by which the need must be satisfied. After that, we assign the technology need to a specific product.

By defining the business need, the timeline requirements and the transition product, we can create an executable plan to satisfy the need. We use this structure to prioritize technology projects based on the timing of the need dates and the ranking of the need in the overall business strategy.

IQ How do technological advances affect safety?

TC

Technology helps improve safety and quality in many ways, but one example is the use of digital twins in product development and testing.

Digital twins allow software developers, engineers and production teams to work on the digital design at the same time, reducing findings when testing the physical product. And digital twins allow us to simulate test conditions that would be unsafe to test with an actual aircraft. The outcomes are safer test programs and safer products.

In production, technology can automate strenuous or repetitive tasks and further enhance producibility, helping mechanics and quality professionals build, monitor and inspect the work more safely and efficiently.

For example, full-size determinant assembly eliminates the drilling of thousands of holes in final assembly and reduces the physical impact on mechanics. Exoskeleton vests support mechanics' shoulders and arms as they work overhead, alleviating fatigue. And robotics will reduce the need for humans to enter confined spaces, diminishing risk.

MAN AND MACHINE

Boeing developed the MQ-25 Stingray, the U.S. Navy's first carrier-based unmanned aerial refueler, with digital engineering. Early testing paved the way for successful demonstrations of the aircraft's deck handling capabilities aboard the aircraft carrier USS *George H.W. Bush* (CVN 77) in 2021.

PHOTO: BOEING

IQ&A

IQ **How does Boeing Research & Technology build on Boeing's best-known technological achievements of the past 100 years?**

TC Boeing holds an unparalleled legacy of engineering firsts, and we keep building on those innovations to continually advance aerospace technologies.

In 1948, six Boeing engineers developed a B-52 concept that was so durable and flexible the aircraft is still in service today. The aircraft plays a pivotal role in the U.S. Air Force bomber fleet and is undergoing multiple modernization efforts that will provide it with new engines and radar to keep it viable and flying until 2050 and beyond.

As prime contractor for the International Space Station, Boeing teams have worked closely with NASA since 1993 to construct, then assemble the ISS on orbit. Boeing is integral in operating, maintaining and sustaining the orbiting laboratory, and those efforts are informing the next generation of low Earth orbit destinations.

And with the introduction of the Boeing 707, the world entered the Jet Age. Faster and more efficient than propeller-driven aircraft, jet-engine airplanes revolutionized aviation. Boeing then introduced the 747, which made global travel possible for people around the world.

Successive generations introduced technologies to enable extended operations and improve airplane efficiency. For example, the first primarily composite commercial airplane, the 787 Dreamliner, makes travel economically viable between more city pairs.

It's important to understand the system you are working on, down to the last detail, and to know how your work fits into the overall project.

You can't just follow the steps in a process. You must understand the "why," so if circumstances change, you're still able to achieve the objective.

A healthy paranoia about what can go wrong will drive you to work to prevent errors.

NEVER BORING

In 1969, Boeing began to test the first Boeing-built composite component, the boron composite wing foreflap, on a 707-320 Intercontinental. Flight testing confirmed the in-service reliability of the new high-strength, low-weight, structural material, which was fabricated from boron filaments. Design engineers said the boron foreflap was 25% lighter than an aluminum foreflap.

PHOTO: BOEING ARCHIVES

IQ **As an engineer and now Chief Technology Officer, what is the best career advice you've ever received?**

TC "Focus on excelling at the job at hand, and your career will manage itself." For me, it's all about technical excellence.

I was fortunate to have Dr. Harold Rosen, co-inventor of the geosynchronous communications satellite, as one of my mentors. He instilled in me that to achieve technical excellence, one needs an intuitive understanding of the work. Otherwise, how do you know your answer is correct?

It's important to understand the system you are working on, down to the last detail, and to know how your work fits into the overall project. You can't just follow the steps in a process. You must understand the "why," so if circumstances change, you're still able to achieve the objective. A healthy paranoia about what can go wrong will drive you to work to prevent errors.

Lastly, it's critical to understand the data coming off the system you're working on. To know the system is working properly, you need to be able to predict what you're seeing down to the last blip in the data.

It's a high bar, but that's what technical excellence requires. IQ

HANDS-ON DECK

Electrical skills adviser Greg Cass, left, guides Mark Kusch and Selena Vo through installing electrical components in the flight deck inside a Next-Generation 737 training structure at the Renton Foundational Training Center.

Something Old, Something New

737 fuselage becomes new training ground for Boeing electricians

BY MALLEY HISLOP, BOEING WRITER
ALL PHOTOS BY MARIAN LOCKHART/BOEING

A Next-Generation 737 forward fuselage section is serving a new mission inside the Renton Foundational Training Center in Washington, providing a real-world training platform for Boeing electricians. And the plan took flight because of employee feedback.

"The 737 team told us that wiring installations in the electrical equipment bay can be especially challenging for new technicians," said training superintendent Damont Smith.

A better solution

Teammates from Product Development, Engineering and Foundational Training set out to develop a new training module to help electricians learn how to wire inside the electrical equipment bay, while also protecting wiring that's already installed.

After they considered building a mock-up of a 737 forward fuselage, the team found a better solution in south Texas.

"The team realized we could transport a Next-Generation 737 fuselage section from Hondo, Texas, to Renton within a few weeks," Smith said. "While some of the components and configurations are different than a 737 MAX, the wiring concepts and the ergonomics — how the electricians work inside the barrel — are nearly identical."

"The team realized we could transport a Next-Generation 737 fuselage section from Hondo, Texas, to Renton within a few weeks. While some of the components and configurations are different than a 737 MAX, the wiring concepts and the ergonomics — how the electricians work inside the barrel — are nearly identical."

DAMONT SMITH,
TRAINING SUPERINTENDENT

NEW LIFE FOR NEXT GENERATION

Damont Smith, right, talks with Dave Potash, left, and Johnny Sourichanh, an Environment, Health & Safety specialist, about the teamwork that brought a Next-Generation 737 fuselage section to the Renton factory floor for training in late 2023.

INSIDE TRAINING

Warren Medina steps through a wiring procedure inside the electrical equipment bay training structure. It is in the underbelly of the fuselage, beneath the flight deck.

Realistic training for all

Aerospace technician Antony Patsan said the realistic environment complements the training module.

"Training in the fuselage before going on the floor helped me see and feel the atmosphere that I'll be working in," Patsan said. "The instructors are very enthusiastic, and their anecdotes of their time on the floor with tips for safety and efficiency are helpful."

The investment is just one answer to teammates' requests to enhance workforce training.

And the fuselage section is serving more than new electricians.

"Training in the fuselage before going on the floor helped me see and feel the atmosphere that I'll be working in. The instructors are very enthusiastic, and their anecdotes of their time on the floor with tips for safety and efficiency are helpful."

ANTONY PATSAN,
AEROSPACE TECHNICIAN

WIRE WORK

Greg Cass, right, instructs Natalie Benefiel as she installs components inside the Next-Generation 737 training structure.

MULTITASKER

The reclaimed Next-Generation 737 forward fuselage section offers Manufacturing trainees and Quality inspectors a realistic look inside the airplane, away from the production line. Boeing engineers step inside the trainer to see, feel and smell the actual product as well. Working in the training space helps engineers refine and improve the work instructions they write for installation and maintenance personnel.

"The environment is so similar to what we have on the flight line now," said Smith. "Anyone who needs to work with the forward part of the airplane — like Quality and Engineering, among others — can use the structure to get hands-on experience."

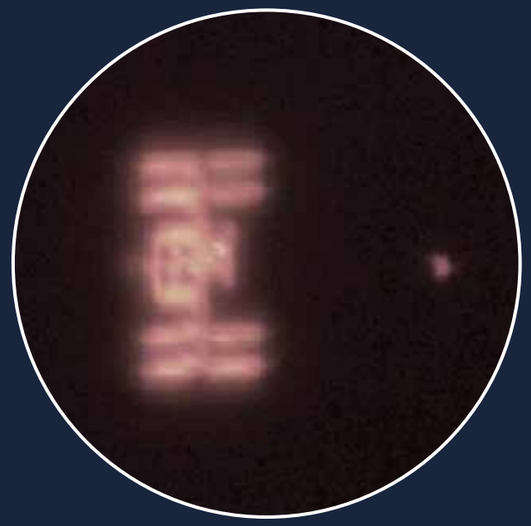
Manufacturing operations analyst Dave Potash agreed. "Engineering can use the fuselage section to determine how engineering changes will impact existing installed parts, systems and even wire bundles," he said. "This training module is proving to be a solution to reduce quality escapes in the electrical systems, and it's a tremendous benefit to electricians, mechanics and inspectors who are responsible for the quality of the aircraft." **IQ**

> "The environment is so similar to what we have on the flight line now. Anyone who needs to work with the forward part of the airplane — like Quality and Engineering, among others — can use the structure to get hands-on experience."
>
> **DAMONT SMITH,**
> **TRAINING SUPERINTENDENT**

Clear as Day

Daytime satellite tracking technology offers around-the-clock views of orbiting satellites

BY JOSH ROTH, BOEING WRITER



As the CST-100 Starliner approached the International Space Station for docking, the Boeing Laser & Electro-Optical Systems team captured the view via telescope from Albuquerque, New Mexico.

The team recorded photos and videos of the historic moment using an advanced daytime satellite tracking system that they designed and assembled for daytime imaging. The system combines a large aperture telescope, a shortwave infrared sensor that can image orbiting satellites in daylight, and a computer-controlled mount that compensates for the Earth's rotation.

NO BLUE LIGHT

Using shortwave infrared sensors that filter blue light, a Boeing telescope in Albuquerque, New Mexico, captures the moment the CST-100 Starliner, right, approaches the International Space Station.

IMAGE: BOEING

GRAPHIC: BOEING

PHOTO: COURTESY OF RON DAUK

> "Our capability uses mostly commercial-off-the-shelf hardware modified with Boeing's radiometric, sensor and inertial navigation technology, resulting in a simple, affordable design that delivers exceptional performance."

RON DAUK,
BOEING MANAGER

PHOTO: COURTESY OF DALE PARKES

> "Satellite observation is key, not only to monitoring activity in orbit but also in developing technologies like satellite laser communication."

DALE PARKES,
BOEING TECHNICAL FELLOW

Daytime satellite tracking could enable around-the-clock monitoring of satellite orbits, which is currently conducted primarily during short periods before sunrise and after sunset. Ambient light tends to overload sensors.

By expanding the time window for satellite tracking, the technology could deliver a variety of potential benefits, including:

- Greater space domain awareness.
- Enhanced early warning capabilities.
- Improved communication and coordination.
- More accurate intelligence via real-time threat monitoring.

"This high-profile event enabled us to demonstrate the value of daytime satellite tracking to a broader audience," said Laser & Electro-Optical Systems manager Ron Dauk. "Our capability uses mostly commercial-off-the-shelf hardware modified with Boeing's radiometric, sensor and inertial navigation technology, resulting in a simple, affordable design that delivers exceptional performance."

The telescope works by following the predicted orbital path of satellites using proprietary software and capturing imagery using shortwave infrared sensors, which reject blue light. That mitigates the traditional problem of daytime tracking and allows greater satellite detection. The system processes the final imagery and enhances its quality.

"Satellite observation is key, not only to monitoring activity in orbit but also in developing technologies like satellite laser communication," said Dale Parkes, system architect and Boeing Technical Fellow. "Our team takes pride in developing novel solutions to our customers' most pressing challenges. We believe this capability will unlock new opportunities and applications for ground-based tracking systems." **IQ**

IQ VIEW
Watch the ISS cross over New Mexico from more than 259 miles (417 kilometers) away. The video has no sound.
VIDEO: BOEING

From ‘What If’ to ‘Watch This’

Engineers demo a new way for manned and unmanned aircraft to talk, and mum is not the word

BY SHANNON VAUGHAN, BOEING WRITER

A four-woman team is leading the charge in creating a new way for manned and unmanned systems to communicate — and it’s all about collaboration.

Members of the Fighters new product development team — Sohaila Mali, Janell Liebel, Jessica Arbona and Lexi Anderson — are combining their diverse skills and perspectives to engineer new ways for humans and machines to communicate, ultimately creating a more integrated and informed battlespace.

TEAM BEHIND THE TEAMING

Sohaila Mali, Janell Liebel, Jessica Arbona and Lexi Anderson are developing new ways for humans and machines to communicate, creating a safe, integrated and informed battlespace.

PHOTO: BOEING

Over a six-month period, the team went from a blank whiteboard to a successful software demo that quickly converts, translates and exchanges messages between different types of platforms.

The current demonstration uses existing Boeing platforms, an F/A-18 fighter jet and an MQ-25 unmanned aircraft system. But this is just the start. The team aims to move from a simulation environment to a potential flight test in 2025. The goal is to demonstrate multi-ship collaborative capabilities — including between manned and unmanned aircraft — to the customer.

Meet the teammates changing the future of manned-unmanned teaming (MUM-T):

NEW CONTACT

In an air-to-air test, an MQ-25 T1 aerial refueling store known as the pod connects with an F/A-18 near St. Clair, Missouri.

PHOTO: BOEING

Talking the engineering language

Sohaila Mali

Since joining Boeing six years ago, Mali has supported several air dominance and commercial satellite programs with her systems engineering expertise. But recently, she stepped out of the testing and simulation lab to drive program strategy.

Mali supports research and investment planning for the new product development team. She combines her technical and business acumen to keep the team's priorities aligned with project funding and the customer's operational needs.

"The work we are doing now will drive more communications capabilities, interoperability and advanced concepts," Mali said. "It will unlock even more potential for how aircraft engage with each other and extend their operational reach across a broad and contested battlespace."

She attributes the team's communication and collaboration as the keys to their success.

"We all talk the engineering language, but we bring different backgrounds and personalities," she said. "We recognize that we each have specific strengths that are needed to accomplish our common goal."

In addition to learning from and laughing with her teammates, Mali takes pride in knowing their daily work goes toward helping the warfighter.

"The aircrew have to do so much all at once, but our work will help alleviate some of the aircrew's stress so they can focus more on the mission," she explained.

> "The work we are doing now will drive more communications capabilities, interoperability and advanced concepts. It will unlock even more potential for how aircraft engage with each other and extend their operational reach across a broad and contested battlespace."
>
> **SOHAILA MALI, PROGRAM STRATEGY**

Thriving on doubters

Janell Liebel

Liebel's official title is systems design engineer, but she describes her role as "if anything unmanned needs to talk to an F/A-18, that's my specialty." With nearly 10 years of Boeing experience, she is responsible for developing human-machine interfaces between tactical fighter platforms and unmanned aerial platforms.

"Most of the drones people think about are actually remotely piloted vehicles, which means there's someone in a bunker actually flying the vehicle," she said. "Whereas the unmanned systems I'm working on are intended to be fully autonomous, so they're making decisions based on inputs from their environment."

> "When we first got funding for the demo, some people said what we set out to do was impossible and that we wouldn't get it done. But the doubters drive us, we thrive on it. We love to prove people wrong."
>
> **JANELL LIEBEL, SYSTEMS DESIGN ENGINEER**

Defining requirements from scratch for a system that can connect a variety of platforms and be seamlessly integrated into various mission scenarios is an extremely complex undertaking, and the result has huge benefits.

"Moving information through the battlespace is one of the most important capabilities we can solve for," Liebel said. "If we can find a way to have fourth-generation platforms easily talk to fifth- and sixth-generation platforms, it will help the U.S. Department of Defense achieve its warfighter goals."

Liebel acknowledges the team has faced challenges but says that doesn't slow them down.

"When we first got funding for the demo, some people said what we set out to do was impossible and that we wouldn't get it done," she said. "But the doubters drive us, we thrive on it. We love to prove people wrong."

The team's ability to work together seamlessly is how it is breaking down communications barriers in the battlespace.

"With our combined skills and talents, we are continuously coming up with new ideas and finding ways to implement them," Liebel said.

UNMANNED-TO-MANNED TALK
An unmanned MQ-25 connects with a manned F/A-18 while flying over Mascoutah, Illinois.
PHOTO: BOEING

Sparking ideas

Jessica Arbona

After more than seven years of engineering mining equipment and being a software consultant, Arbona joined Boeing four years ago in pursuit of problem-solving for more complex platforms.

She has found her place on the Fighters new product development team, focusing on open mission systems (OMS) to enable rapid software integration across defense platforms.

"I evaluate the current architecture, research what is needed to support the future capabilities, establish the assumptions and test via prototypes," she said.

With input from Liebel on the MUM-T requirements, Arbona leads a team of software engineers who are tackling battle management and creating a common interface for rapid tactical third-party application integration. Currently, it can take years to push software updates across platforms, so streamlining this process will reduce aircrew workload and get new capabilities to the warfighter faster.

> “There’s no fear in sharing questions and ideas. We push each other and learn from one another’s confidence and expertise.”
>
> **JESSICA ARBONA, FIGHTERS DEMO LEAD**

Arbona highlights the team’s collaborative spirit, saying, “There’s no fear in sharing questions and ideas. We push each other and learn from one another’s confidence and expertise.”

That motivation also encouraged Arbona as she used the Boeing Learning Together Program to complete her executive Master of Business Administration from Auburn University, adding leadership and business acumen to her skill set.

“The program allowed me to pursue the degree I had always desired,” she said. “And it was a wonderful feeling to join my family in becoming a part of the Auburn community, as both my parents and sister are alumni of the university.”

Her ability to manage multiple projects and time lines is a talent that has helped the team set realistic goals, break down plans into tactical steps and stay on schedule.

“It felt really good that the customer was pleased with the progress,” Arbona said. “But what was even better was being with the team when we saw it work for the first time. That moment was unforgettable and lit a spark in all of us to keep taking this further.”

Proving the possible

Lexi Anderson

Anderson joined Boeing two years ago as a technical integrator, but she’s been taking things apart and figuring out how they work since she was 9. Her mother worked at a medical device company, and Anderson would take advantage of any chance she got to connect with the engineers in the office.

“When my electronics broke at home, I would diagnose it and then ask my mom to take it to her co-workers to fix and resolder it,” she said.

Now, she’s the teammate others turn to for solutions. Her area of expertise is data analysis and integration. As Liebel and Arbona identify the minimum MUM-T and OMS requirements, Anderson uses that to inform how the data, or messages, must be packaged to deliver the right information in the right size.

“I determined the most useful fields and created a native language so that systems can speak either ship-to-ship or jet-to-jet,” she said.

IN THE WINGS

Under a constant reminder of the warfighters’ mission, Fighters teammates say the mission drives serious collaboration and their quest to create new capabilities for aircrews and defenders.

PHOTO: BOEING

The teamwork to modify and truncate the messages was a success. When the simulation was completed for the first time, it was a moment of victory and validation.

“We hypothesized that we could do these weird things with messages and basically take them apart and reassemble them on the other side,” Anderson said. “But seeing it actually happen is a huge sense of accomplishment.”

“At some point, all engineers likely ask themselves, ‘is what I’m working on possible — can it be done?’ and this was affirmation that it could,” she added.

The team knows customer relationships and, most importantly, lives will be impacted by this work.

“When customers come to us asking about capabilities, we know it’s because they trust us, and it’s necessary to keep the warfighter safe during missions,” Anderson said. “We take that responsibility very seriously and with honor.” **IQ**

MUM-T MOMENTUM

Anderson, Arbona and Liebel collaborate to identify MUM-T and OMS requirements, package data and streamline software updates across defense platforms.

PHOTO: ERIC SHINDELBOWER/BOEING

> “We hypothesized that we could do these weird things with messages and basically take them apart and reassemble them on the other side. But seeing it actually happen is a huge sense of accomplishment.”
>
> **LEXI ANDERSON, TECHNICAL INTEGRATOR**

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BOEING

MATERIAL MACHINE

Custom machine adds vertical production to vertical lift

BY MELISSA BOBAN, BOEING WRITER
ALL PHOTOS BY FRED TROILO

Inside the Boeing Composite Center in Philadelphia stands a single automated tape layup (ATL) machine, developed by Boeing engineers especially for rotor blade production.

Just months into its life span, the ATL machine envisioned a decade ago by Boeing engineer Steve Cullison is creating huge efficiencies.

“The last machine of this kind was built in 2003, and it went through phases of layup, quality and maintenance issues,” said Cullison. “About four years ago, we began to understand how to better use new technologies through a new ATL machine that would offer tremendous improvements in quality and throughput.”

BLADE MAKER
Engineers Hans Mehling, left, and Steve Cullison check the settings of the ATL machine. Developed over the past several years, the one-of-a-kind machine fabricates rotor blade components for the H-47 Chinook more efficiently.

> “Every bit of time saved frees up capacity to increase production, and each improvement ultimately leads to a better aircraft.”
>
> STEVE CULLISON, BOEING ENGINEER

> “About four years ago, we began to understand how to better use new technologies through a new ATL machine that would offer tremendous improvements in quality and throughput.”
>
> **STEVE CULLISON, BOEING ENGINEER**

TAPING TECHNIQUE

Composite fabricator Matt Haldeman inspects a section of tape that will become part of the inner structure of a rotor blade.

Plying it on

Boeing teammates use the ATL machine to fabricate uniform rotor blades for the H-47 Chinook. The heavy-lift helicopter, operated by the U.S. Army and defense forces of 20 other nations, is known for its ability to adapt to rugged terrain. The H-47 Chinook can fly up to 20,000 feet (6.1 kilometers) and haul over 27,000 pounds (12.2 metric tons). To do that, the helicopter relies on its powerful rotor blades.

To create the internal structural components of a rotor blade, the ATL machine layers ply packs, or plies, on top of one another, then slits each stack-up to create multiple parts. Operators used to trim each ply layer by hand to ensure standard conformance.

Cullison proposed a concept for a rotating head for the machine that allows bidirectional tape layup, layering the plies both horizontally and vertically. Switching to vertical tape layup offers three benefits — greater layup and trimming accuracy, improved material quality and less weight variability in final assembly.

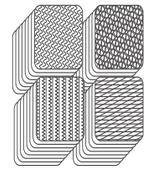
Saving four production hours per blade and cutting almost three hours of manual labor per blade, teammates can devote more time to collecting production data and improving production quality. They are also scrapping fewer parts and reducing waste along the way.

Automation advancements

The composite manufacturing industry at large was a source of ideas for Cullison as he developed requirements for the new ATL machine.

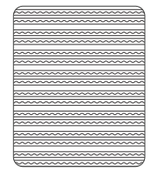
“Insights from an enterprisewide automation project, site visits and technical conferences helped me understand how to implement newer technologies into our production system,” Cullison said.

For example, he discovered that configuring horizontal vacuum tables vertically helped to better manage film releases and parts handling. Suction constrains the release film and supports the laid up parts, easing the manufacturing process.



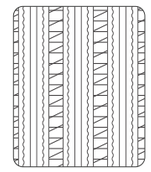
PLY PACKS

Each ply stack-up, or ply pack, varies. Up to 19 different ply pack designs contribute to the blade’s strength and durability.



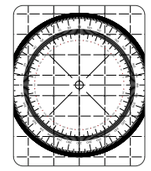
LAYERED LOOK

Over 100 layers of composite resin glass fibers create a candylike pattern in the tape. A cure cycle softens the material, then hardens it, before moving to the next stage of production.



TACKY TAPE

The composite material is known as pre-impregnated tape, referring to its ability to adhere with other layers. More tacky than sticky, the material is coated in resin and epoxy, and the tacky glass fibers solidify when cured.



LASER RULER

Lasers measure the thickness of the rotor blade components, which are about 30 feet (9 meters) long, or about the length of a school bus.

IDEAS TO IDEALS

Engineering manager Peggy Castaneda routinely visits the production area to check the ATL machine's performance, collect production data and discuss ideas for improvements with the team.

> “Anytime we innovate our processes, the technical challenges come with it, so it’s not a smooth journey. To make it work is huge.”
>
> **PEGGY CASTANEDA, ENGINEERING MANAGER**

Bumpy to smooth

Cullison and his teammates navigated many challenges on the road to smooth production, and their persistence paid off.

“You can’t buy this type of machine off the shelf, and you don’t know what you’re dealing with until you cross the bridge,” said engineering manager Peggy Castaneda.

In hours of trial and error, the team stayed motivated, pushing through doubts to find new solutions in additive manufacturing or through spool tension optimization. When the challenges piled on, the solutions flowed, and now the final result is in use on the floor.

“Anytime we innovate our processes, the technical challenges come with it, so it’s not a smooth journey,” Castaneda said. “Talented engineers find a way to make things work. They overcame many challenges and worked together to implement this equipment. To make it work is huge.”

LAYER BY LAYER

Quality inspector Drew Lowry watches the tape layup process as the ATL machine does its work.

What’s next?

After using the new ATL machine for about a year, Cullison and his teammates are collecting data to assess the machine’s reliability and sustainability. As they continue evaluating their fabrication processes, they are considering other uses for the machine and looking to further enhance its efficiency. For example, they are studying ways to reduce the number of material spool changes.

“Every bit of time saved frees up capacity to increase production, and each improvement ultimately leads to a better aircraft,” Cullison said. “We’re always looking into technologies to improve processes, increase efficiency, and improve the safety and quality of our products.” **IQ**

LOADS BETTER

Haldeman starts the fabrication process by loading a short section of tape into the ATL machine. The new machine’s design reduces time spent loading tape.

Trailing Contrails

PHOTO: PAUL WEATHERMAN/BOEING

The Boeing ecoDemonstrator Explorer, a 737-10 destined for United Airlines, flies through cold, humid air at 35,000 feet (10,668 meters), leaving in its wake a wispy vapor trail known as a contrail.

Contrails are clouds made up of ice particles that form when water in the air condenses on particles from engine exhaust and freezes when exposed to cold temperatures at high altitudes.

As the Explorer alternates between 100% sustainable aviation fuel (SAF) in one tank and conventional jet fuel in the other, NASA's DC-8 Airborne Science Lab follows 5 miles (8 kilometers) behind to measure the emissions of each fuel.

> "Contrails appear to have a contribution to the climate impact of airplanes and their emissions. The persistence of the contrails — how long they last — can make a difference, so we're studying how a lean combustor and cleaner sustainable fuels can affect the contrails' characteristics."
>
> **STEVE BAUGHCUM,**
> **BOEING TECHNICAL FELLOW**

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