

INNOVATION QUARTERLY

INNOVATION. INSIGHT. INSIDE AEROSPACE.

Liquid Asset

The way to
net zero is fluid

PLUS: Augmented Reality
Aerial-dogfighting tech
advances fighter-pilot training



FUTURE REFERENCE

Engineer Carissa Pajel is part of the team that created a jet reference fluid for sealants immersion lab testing.



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Cover Story
Team aims to deliver
100% sustainable aviation
fuel-capable airplanes
by 2030.

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the trail for today's spacecraft.



Momentum

Onward and upward

Momentum is a crucial principle in aerospace — a fundamental variable that contributes to the miracle of flight. Yet the composition of momentum — mass and velocity — transcends physics and is the ideal metaphor for our company. The collective mass generated from our creativity, discipline and passion propels each facet of our work as we pursue new horizons.

We connect, protect and explore the world through innovation. Look closely throughout this publication for evidence of momentum across our enterprise.

The cover story spotlights the momentum behind sustainable aviation fuel. In particular, the article delves into a Boeing-developed jet reference fluid that mimics synthetic fuels — and can then be used to test airplane components.

This edition also highlights next-generation aerial-dogfighting training. Using augmented reality, fighter pilots can see and interact with aircraft, targets and threats on the ground or in the air while flying and training in their actual aircraft.

The push deeper into outer space builds on the innovation of the past. Celebrate a 30-year anniversary with a classic photograph of the first reusable rocket.

And on the ground, continuous momentum on the runway is vital for airlines. A new device enables operators to transfer data quickly to help evaluate the health of their fleets.

We invite you to read on and ride the momentum, page by page. IQ

Naveed Hussain
Vice President and Chief Engineer,
Boeing Engineering, Test & Technology

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

Direct Connection

New device transfers airplane data quickly to help airlines evaluate and monitor the health of their fleets

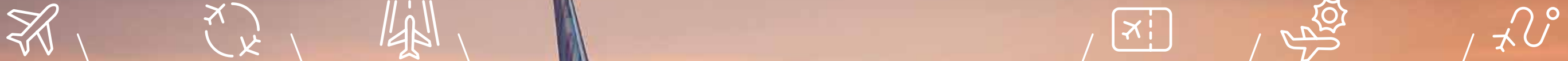
BY MAKSIM GOLDENSHTEYN AND MYCHAELA KEKERIS, BOEING WRITERS

High-speed, high-bandwidth data communication between airplanes and ground operations is no longer an option — it is a necessity.

Airlines constantly monitor the health of each aircraft, checking its onboard data and running diagnostics to make sure the airplane is ready for its next flight. Flight hours, weather conditions and other factors create wear and tear on airplanes, just as mileage affects a vehicle's performance.

To optimize maintenance schedules and plan fleet operations, operators check an airplane's performance data after each trip. Proactive management informs the airline's schedule decisions, as the data indicates when an airplane will be ready for its next departure.

A new Aircraft Interface Device (AID), designed and built by Boeing AvionX, now enables operators to pull real-time aircraft data over Wi-Fi and 4G LTE cellular networks, informing operations decisions for entire fleets.



CROWN JEWEL

Mounted in the crown of an airplane, the Boeing AID provides operators onboard and offboard connectivity.

IMAGE: BOEING



Without an AID-type device, maintenance teams physically walk to the airplane and offboard the data manually. With an AID, operators can read an airplane's data from the back office as soon as the airplane lands and connects over Wi-Fi or a cellular network. The AID conveniently supports software updates and requests for data for an entire fleet.

On some airplanes, a single AID consolidates the off-board Wi-Fi and 4G LTE cellular functionalities that had been provided by two separate units. As 3G networks phase out around the world, the AID will replace those older devices to provide 4G LTE connectivity.

IT'S WHAT'S INSIDE THAT COUNTS

The AID connects to an antenna on the exterior of the airplane and to the hub of airplane data. The array of black cooling fins counters the heat in the crown of the airplane.

PHOTO: DEAN PIERETTI/BOEING



IN THE BAG

The AID makes onboard connections to electronic flight bags using Wi-Fi.

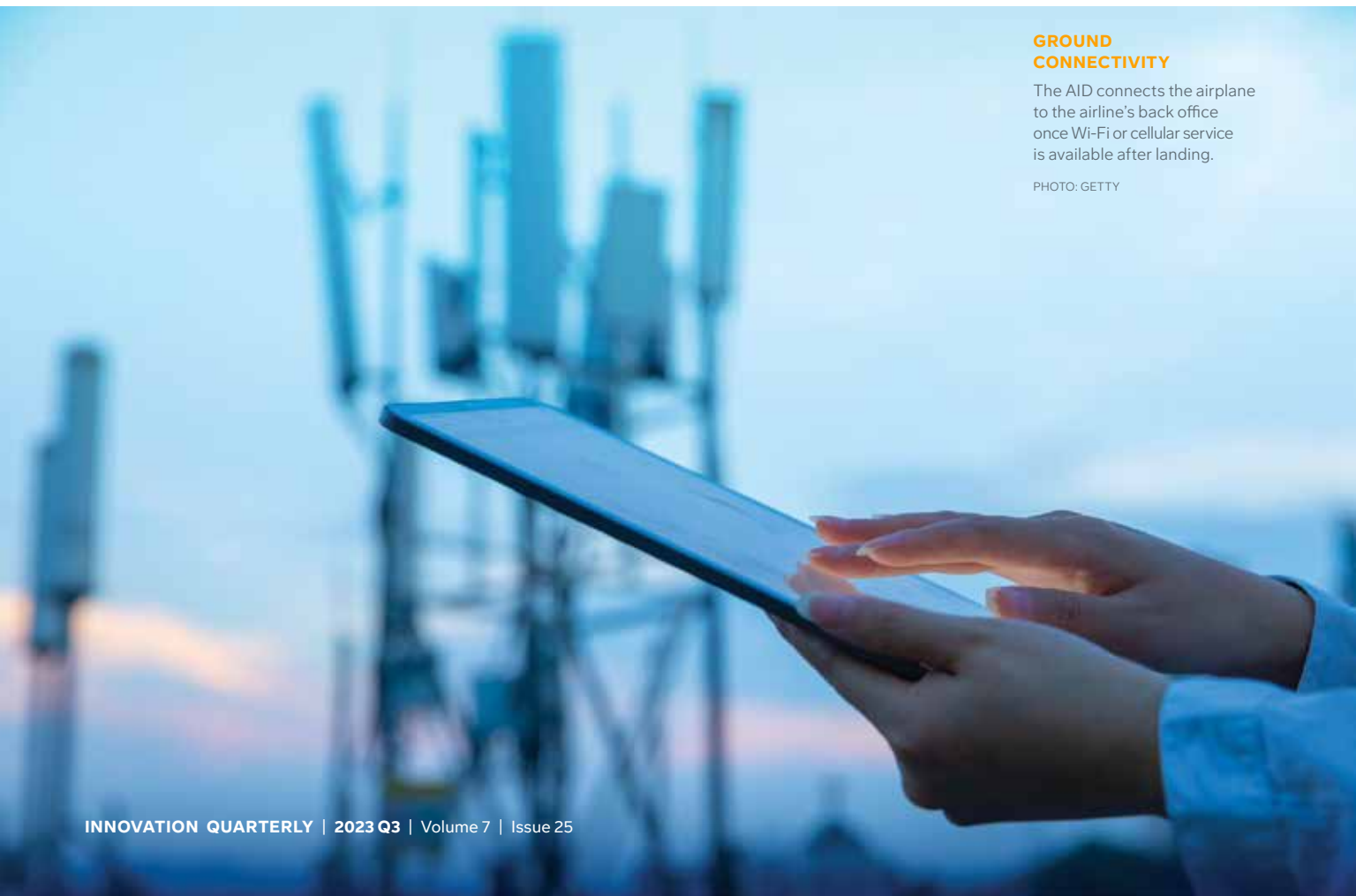
PHOTO: BOEING



GROUND CONNECTIVITY

The AID connects the airplane to the airline's back office once Wi-Fi or cellular service is available after landing.

PHOTO: GETTY



“Airlines will reduce maintenance tasks by receiving data faster to make decisions faster, and that means more efficient airline operations. The AID expands Boeing’s ability to design and produce avionics products to support our commercial airplane programs.”

**PER BEITH,
VICE PRESIDENT,
BOEING AVIONX**

With Wi-Fi connectivity, the AID enables pilots and mechanics to connect their wireless personal electronic devices or electronic flight bags, connect maintenance laptops to transfer aircraft data, and use apps like those for weather and navigation.

Airlines can configure the AID software to suit their needs for onboard and offboard connectivity, depending on the aircraft model.

Boeing has produced more than 1,400 of the devices, which are made in Smithfield, Pennsylvania. More than 400 devices have been delivered on Boeing airplanes, and the AID will be standard on all in-production commercial airplanes. The AID also will be available to add to Boeing commercial airplane models already in service.

“Airlines will reduce maintenance tasks by receiving data faster to make decisions faster, and that means more efficient airline operations,” said Per Beith, vice president of Boeing AvionX. “The AID expands Boeing’s ability to design and produce avionics products to support our commercial airplane programs.” **IQ**

FUTURE REFERENCE

Boeing engineer Carissa Pajel pours jet reference fluid into a jar for sealants immersion testing in a laboratory.

PHOTO: BOEING



Liquid Asset: The Way to Net Zero Is Fluid

Team aims to enable 100% sustainable aviation fuel-compatible airplanes by 2030

BY ELISA HAHN AND ED MUIR, BOEING WRITERS

Inside a laboratory, Boeing engineer Carissa Pajel pours fluid into a glass beaker – a clear substance that could be liquid gold.

A cross-functional Boeing team will use the liquids, known as jet reference fluids (JRFs), to understand how airplanes interact with 100% sustainable aviation fuel (SAF).



“Our systems and materials on our airplanes were designed for conventional jet fuel. Now that we’re moving to cleaner and more efficient fuels, which may not have some of the chemical compounds of petroleum-based jet fuels, we need to make sure our systems are compatible.”

J.P. BELIERES,
 PROPULSION SYSTEMS DIVISION,
 ENGINES AND FUELS TECHNICAL FELLOW



TEST TEAM

(From left) Mindy Miller, Product Development Advanced Materials Associate Technical Fellow; Pajel, Boeing Research & Technology Materials Process and Physics engineer; J.P. Belieres, Propulsion Systems Division, Engines and Fuels Technical Fellow; and Ilya Kosilkin, Fuel Properties group lead, developed the JRFs in Boeing’s laboratory in Seattle.

PHOTO: BOEING

**The Challenge:
 Getting to 100% Compatibility by 2030**

Pajel is part of Boeing’s SAF Aircraft Compatibility Integrated Product Team. They are tackling the technical challenge to ensure all the commercial airplanes Boeing delivers can fly on 100% SAF by 2030.

Two years ago, Boeing committed all its commercial airplanes will be 100% SAF-capable by 2030. SAF has the potential to reduce carbon emissions by up to 80% over the fuel’s life cycle.

“Our systems and materials on our airplanes were designed for conventional jet fuel,” said Propulsion Systems Division, Engines and Fuels Technical Fellow J.P. Belieres.

“Now that we’re moving to cleaner and more efficient fuels, which may not have some of the chemical compounds of petroleum-based jet fuels, we need to make sure our systems are compatible.”

This includes testing anything fuels come into contact with on the airplane – primers, sealants, finishes, metals, composites and O-rings, for example.

FUEL FOR THOUGHT

A vial of SAF sits in a Boeing laboratory.

PHOTO: BOEING



SAF FACTS
 What you need to know.



The Achievement:
A Reference for Testing SAF Interaction

The team reached a significant testing milestone by successfully developing a SAF JRF, the first in a variety of fluids that mimic the chemistry and behaviors of sustainable aviation fuels. The chemical makeup of SAF can vary depending on the feedstock and refining process. With this in mind, the team developed the JRFs to test how SAF interacts with airplane materials differently from conventional petroleum-based jet fuel.

Pajel and team, for example, will immerse sealants in the JRFs to see how the sealants behave when exposed to SAF for certain durations and temperatures.

GOOD POUR

Pajel uses the JRF to test sealant by soaking it in the fluid for various periods of time and at a variety of temperatures. The goal is to determine any effects on sealant performance. Sealant is used in several areas of the airplane, such as the fuel tank.

PHOTO: BOEING



SAF COMPATIBILITY SUPPLIER SYMPOSIUM

Boeing invited more than 20 suppliers from around the world to Seattle in April 2023. The first-of-its-kind event unveiled the JRFs, proposed compatibility testing and encouraged shared learnings across the commercial aviation industry.

PHOTO: BOEING



Why It Matters:
Net Zero in Sight

“To reach net zero by 2050, SAF is required,” said Sheila Remes, vice president, Environmental Sustainability. “And while SAF is the answer, it isn’t an easy answer. There is so much work to be done in scaling SAF.”

What’s Next:
Supplier Collaboration

“The team’s achievement allows Boeing to move into a new phase of collaboration with our engine manufacturers, suppliers and SAF producers. This enables a collective focus on reducing the environmental impact of our industry,” said Product Development Associate Technical Fellow Mindy Miller.

“It is the true spirit of sustainable aerospace together.”

In addition, these fluids can serve as a standardized reference for the industry to enable testing of various materials that come into contact with SAF on an airplane. Boeing is already requesting that suppliers conduct similar assessments. **IQ**

“The team’s achievement allows Boeing to move into a new phase of collaboration with our engine manufacturers, suppliers and SAF producers. This enables a collective focus on reducing the environmental impact of our industry. It is the true spirit of sustainable aerospace together.”

MINDY MILLER,
PRODUCT DEVELOPMENT,
ASSOCIATE TECHNICAL FELLOW

CASCADE EFFECT
 Discover Boeing’s
 net-zero modeling tool.



Augmented Reality: Check

Aerial-dogfighting tech to advance fighter-pilot training

BY JENNIFER NON AND RANDY JACKSON, BOEING WRITERS

The future of flight training will take fighter pilots into an augmented world.

Boeing and augmented reality developer Red 6 are collaborating on aerial-dogfighting training technology — to potentially use for the T-7 and F-15EX, two of Boeing's most advanced tactical aircraft.



IMAGE: RED 6

Using the system, pilots can see and interact with AR aircraft, targets and threats on the ground or in the air while flying and training in their actual aircraft. This reduces the cost of and need for multiple platforms and real-world training exercises.

“Our investment in this tech shows our drive to leverage the latest innovation and plug into the most effective training for fighter pilots,” said Jenn Weber, director of Boeing Global Services training.

NEXT-GEN TRAINING

The F-15EX uses advanced training technologies.

IMAGE: BOEING





According to Red 6, the training enables a multitude of tactical scenarios delivered through AR. These include air combat maneuvers, refueling, tactical formation and surface-to-air weapon engagements. It also increases the efficiency of mission planning, briefing and debriefing through real-time 3D visualizations to construct and reconstruct sorties.

By embracing AR, more pilots can be trained more efficiently at lower cost, ensuring they're ready for any scenario in any battlespace. **IQ**

FIGHT IN FOCUS

Fighter pilots get as close to the real thing as possible.

IMAGE: BOEING/RED 6

“ Our investment in this tech shows our drive to leverage the latest innovation and plug into the most effective training for fighter pilots.”

JENN WEBER,
DIRECTOR OF TRAINING,
BOEING GLOBAL SERVICES



COCKPIT POINT OF VIEW

The AR helmet can be worn in the actual aircraft during flight.

IMAGE: BOEING/RED 6

AIR FORCE ONE ARRIVAL

February 1972 in Beijing, Chinese officials await then-U.S. President Richard Nixon and first lady Pat Nixon as they exit *Air Force One*, a modified 707.

PHOTO: NATIONAL ARCHIVES



Going for the Golden

Boeing and China
celebrate five decades
of deliveries

50

TOUR TIMELINE

- Nixon proclaimed his tour “the week that changed the world.”
- Boeing delivered China’s first 707 a year and a half later.
- The visit catalyzed Boeing’s relationship with China that continues today.

FIRST ONE

Boeing employees and Chinese officials in Seattle send off China's first Boeing aircraft to Shanghai in August 1973. The 707 was one of 10 ordered in the wake of Nixon's surprise trip.

PHOTO: BOEING ARCHIVES



Going for the Golden

Boeing and China
celebrate five decades
of deliveries

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HUB FROM ON HIGH

Boeing Zhoushan Completion and Delivery Center is one of the latest examples of mutually beneficial cooperation between Boeing and China's aviation industry.

PHOTO: BOEING



INVICTUS GAMES

EXCITED FOR THE FUTURE

Officer Cadet Rachel Kerrigan served in the Royal Australian Air Force from 1997-2007.

PHOTO: RACHEL KERRIGAN

Boeing engineer and veteran goes from surviving to thriving

BY BELINDA EGAN, BOEING WRITER

Rachel Kerrigan's deployment to Afghanistan changed her life forever.

An engineer with the Royal Australian Air Force, Kerrigan saw active service with the International Coalition Against Terrorism in 2002.

Five years later, a series of life events triggered trauma from her deployment, and she was medically discharged. By 2010, she was diagnosed with severe post-traumatic stress disorder (PTSD) and chronic-depressive disorder and suffered a stress-induced stroke.

"I couldn't leave the house and was told I would never work again. I went from having everything to having nothing," Kerrigan said.

'I Would Not Be Here Today Without the Invictus Games'

TRUE STRENGTH

Today, Kerrigan looks to the future, using her experience to help others.

PHOTO: INVICTUS AUSTRALIA

“ The real power of Invictus isn’t the competition. It’s being surrounded by people who understand your journey. I didn’t win my events, but the Games helped me to celebrate how far I’d come. I’d found my ‘family’ and my purpose again.”

**RACHEL KERRIGAN,
BOEING DEFENCE AUSTRALIA**



The Journey to Recovery

The turning point for Kerrigan was encouragement from her 8-year-old daughter, Kiara, to apply for the Invictus Games.

With maturity beyond her years, Kiara fashioned gym equipment out of broomsticks and buckets and her mom began to train — slowly reclaiming self-belief and a sense of identity. Rachel lost 60 kilograms (132 pounds) and built the physical and mental strength to represent Australia in powerlifting and indoor rowing at the 2016 Invictus Games in Orlando.

“The real power of Invictus isn’t the competition. It’s being surrounded by people who understand your journey,” Kerrigan said. “I didn’t win my events, but the Games helped me to celebrate how far I’d come. I’d found my ‘family’ and my purpose again.”

Kerrigan went on to compete in powerlifting and the National Women’s Wheelchair Basketball League and embarked on a mission to help others, working as a Veteran Engagement Specialist with Invictus Australia.

UNCONDITIONAL BOND

Kerrigan says her daughter Kiara always was, and always will be, a bedrock of support, seeing beyond her mom’s illness to the true person within.

PHOTO: RACHEL KERRIGAN

PUSHING HER LIMITS

Stronger than ever mentally and physically, Kerrigan achieved third place at the 2017 Australian Masters Games. Her personal best is 150 kilograms (330 pounds).

PHOTO: RACHEL KERRIGAN



DAY OF REFLECTION

To observe Australia’s Anzac Day, Kerrigan wore her service medals. Daughter Kiara wore replicas to proudly honour her mother’s and great-grandfather’s military service.

PHOTO: RACHEL KERRIGAN

BACKYARD FRIENDS

At home, Kerrigan enjoys spending time with her beloved horses, Hannah and Summer. She says she's now in a better place than ever.

PHOTO: RACHEL KERRIGAN



Dream Job at Boeing

Today, Kerrigan works as an engineering capability leader in Mission Systems and Ground Systems at Boeing Defence Australia.

“I had always wanted to work at Boeing, but my illness had taken away the part of me that loved engineering, the defence industry and aircraft,” said Kerrigan. **“Invictus kick-started a journey of discovery and opportunity for me. Now I work full time in a demanding role, leading a great team — I thought I would never do this again.”**

Kerrigan draws on the qualities she learned from her recovery and time as a competitor to support colleagues and veterans in the workplace.

“Everyone has a story. Everyone has stuff going on in their personal lives and in their work lives. Perspective is important, and I’m grateful to be able to give back for all of the support that has been given to me.

“And that’s why sponsorships such as Boeing’s of the Invictus Games are so meaningful. It’s hard to put into words how much it means to be given an opportunity that changes your life. To give someone a chance to find out they’re more powerful than what they’re told — to inspire hope and courage.”

“ Everyone has a story. Everyone has stuff going on in their personal lives and in their work lives. Perspective is important, and I’m grateful to be able to give back for all of the support that has been given to me.”

**RACHEL KERRIGAN,
BOEING DEFENCE AUSTRALIA**

Looking to the Future

“PTSD never goes away, but it doesn’t define who I am anymore,” said Kerrigan. “My recovery through sport has given me the clarity to focus on what’s important in life — my family, being true to who I am and using my experience to help others.

“It has shown me that no matter what has happened, I am strong, I am where I belong, and I can be who I want to be.

“I would not be here today without the Invictus Games.” **IQ**



INVICTUS INFO
Dive into the Games.

Proud Partnership

Event	Invictus Games Dusseldorf 2023 Presented by Boeing
Dates	Sept. 9-16, 2023
Competitors	500
Nations	22
Sports	10

This year, Boeing expanded its support, serving as Presenting Sponsor of the Invictus Games Dusseldorf 2023.

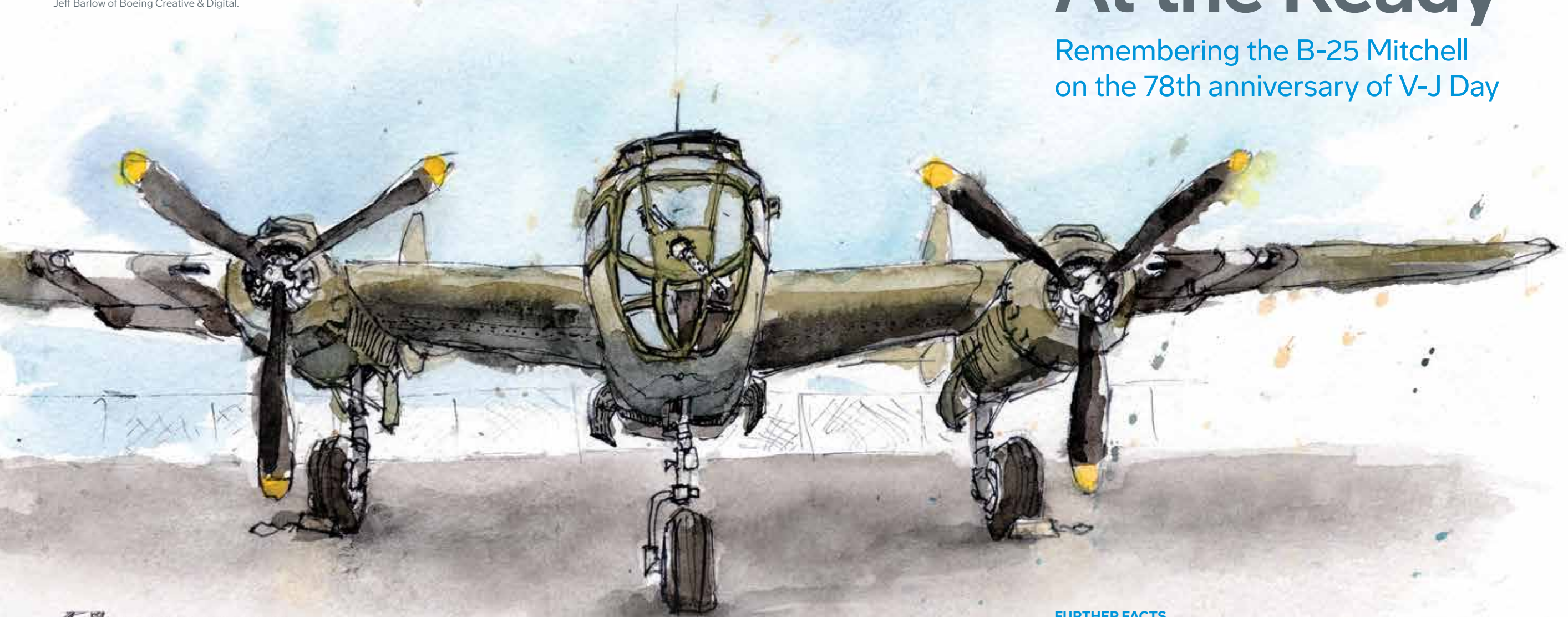
The Invictus Games use the power of sport to inspire recovery, support rehabilitation and generate a wider understanding and respect for wounded, injured and sick veterans.

RESTING ON THE RUNWAY

A B-25 stands at attention in Seattle, captured in pen, pencil and paint by Jeff Barlow of Boeing Creative & Digital.

At the Ready

Remembering the B-25 Mitchell on the 78th anniversary of V-J Day



GRUMPY
B25 at the
MUSEUM of FLIGHT

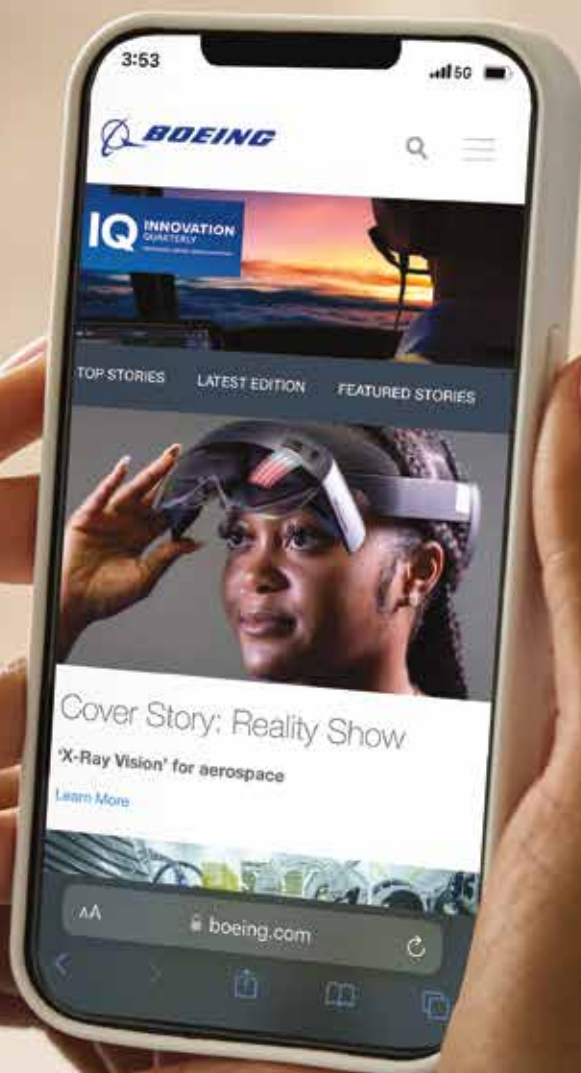
FURTHER FACTS

- Boeing heritage company North American Aviation built nearly 10,000 B-25s.
- Nicknamed “Grumpy,” this aircraft is one of approximately 40 still flying.
- The aircraft played a major role in the Pacific theater during World War II, including the famous Doolittle Raid.
- V-J Day (Victory over Japan Day) commemorates Aug. 14, 1945, when then-U.S. President Harry S. Truman announced imperial Japan’s unconditional surrender. V-J Day is also recognized on Sept. 2 when the Instrument of Surrender was signed, officially ending the war.

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PHOTO: INSTA_PHOTOS/GETTY

First Ascent

Thirty years ago, the original reusable rocket blazed the trail for today's spacecraft



VEHICLE

Delta Clipper Experimental (DC-X)

HISTORYMAKER

First reusable rocket
First to demonstrate vertical takeoff and landing

LIFTOFF

Aug. 18, 1993

LOCATION

White Sands Space Harbor in New Mexico, U.S.

FLIGHT DURATION

59 seconds

ALTITUDE

46 meters (151 feet)

BUILDER

Boeing heritage company McDonnell Douglas

PHOTO: BOEING ARCHIVES

Join our team



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