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Frontiers

Vision quest

Boeing technology allows unprecedented realism for military flight simulators

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PHOTO: TIM REINHART | BOEING

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Cover: A pilot flies a mission in a simulator using Boeing's Constant Resolution Visual System, or CRVS. **BOB FERGUSON | BOEING**

Photo: A composite view of what a pilot sees when training with the CRVS Landscape, an alternative to the standard 360-degree CRVS. **RON BOOKOUT | BOEING**

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The stories behind the ads in this issue.

The deluxe edition of *Higher: 100 Years of Boeing*, a new book about Boeing's history, has 64 pages of photographs not included in the standard retail edition—and it's available only from the Boeing Store. Get your copy now at your local Boeing Store or boeingstore.com.

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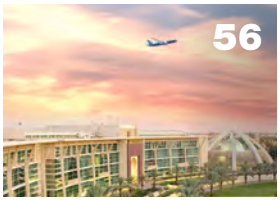

Part of Boeing's Middle East "Together" campaign, this ad highlights Boeing's investment in higher education in Saudi Arabia. Translated, the text reads: Together we invest. As a pioneer supporter of the Saudi education sector, Boeing is proud to have co-founded Alfaisal University in Riyadh to support student research in various fields such as engineering, science, business and medicine.

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Author Russ Banham worked closely with Boeing to develop this fascinating new history of the company's first century. The deluxe hardcover edition, available only from the Boeing Store, comes in a special slipcase and contains nearly 300 pages of inside stories and rare photographs that tell how Boeing and its heritage companies came into being and transformed the world. Get your copy now at your local Boeing Store or at www.boeingstore.com. $49

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SNAPSHOT

Magic Carpet ride

An F/A-18 Super Hornet lands on the deck of a U.S. Navy aircraft carrier using a new software technology known as Magic Carpet that allows more accurate and consistent landings. Boeing and the Navy recently tested the technology during successful sea trials on board the USS *George H.W. Bush*. The software is designed to change how flight controls on an aircraft work, allowing pilots to rapidly move the flaps instead of rotating the aircraft.

PHOTO: U.S. NAVY

QUOTABLES

"Aircraft like the 787 enable us to fly to destinations we otherwise wouldn't."

—Jeff Smisek, chairman, president and CEO for United Airlines, on United's new San Francisco to Chengdu, China, route, which he said was made possible by the 787's efficiency. If it's successful, the airline will follow it with other new long-haul, nonstop international routes. *Buying Business Travel*, July 16

"If we ever stopped to think about what we were trying to do, I'm not sure we'd have attempted it!"

—Ginger Barnes, retired Boeing vice president and program manager for Space Launch Systems, on helping integrate the Russian element of the International Space Station in 1988. Read Barnes' story, and those of other employees, customers and aviation enthusiasts, on Boeing's centennial story sharing website at boeing.com/our-stories.

"We have to shop the world for ideas."

—Tim Noonan, Boeing vice president of Training Systems and Government Services, on how Boeing is meeting with video and computer game experts across the globe to improve its simulation offerings and collaborate on advanced projects. *Boeing News Now*, July 16

Burning desire

This Boeing firefighter's training prepared him for any emergency

BY CAPT. MIKE SIGNORA, AS TOLD TO MEGAN GALVIN

As captain of A Platoon at the Boeing Fire Department at the Philadelphia site, Mike Signora is passionate about safety and helping ensure fires and other emergencies are rare events at Boeing.

I remember once seeing a poster on a firehouse wall that said, "In case of fire, break glass." It depicted a little fireman inside a firebox with a hose and an axe, just sitting there ready to go. I always thought that was funny because that's how I think. As a Boeing firefighter I'm always ready to go. If a fire happens, I want to be there.

Actually, at the Boeing Philadelphia site, my days are spent mostly on prevention. It's a diverse site where we build Chinooks and V-22s, manufacture composites, and test, design and engineer the products our customers depend on.

As the captain of the A Platoon, I lead my team through the site daily—on 24-hour shifts—inspecting, testing and monitoring fire alarms, sprinklers, extinguishers and fire-rated materials. Essentially, my job is to keep our people safe so they can go on designing and building the products that keep the world safe.

Philadelphia is a pretty cool part of Boeing. I get to work on the flight ramp whenever Chinook helicopters roll from the factory floor into flight testing. The pilots appreciate the safety net, knowing we're a step away and ready to support any aircraft situation that might arise. Their lives are in my hands. I don't take that lightly.

No one wants a fire to happen. But if it does, I know I'm fully prepared. I've been trained in engine, truck, hazmat, aircraft rescue firefighting, emergency medical services and confined-space capabilities. I feel like I can handle almost anything you throw at me.

A few years ago that training came into play for me, during an accident just outside the facility. Two semi-trucks crashed on Interstate 95 and because of the magnitude of the crash and resulting fire, local authorities called in my Boeing fire unit to help get the scene under control. They knew we could get the job done. That's a good feeling.

One of my favorite things about working for Boeing is getting to work side by side with my childhood buddy Shawn. His father was a volunteer firefighter at the Prospect Park Fire Company just down the road from Boeing. When Shawn joined that department, I started hanging out at the fire station too—and found my calling.

A few years ago I even became the chief at that local fire station. It's all come full circle. And when it comes time to break that glass, I'm ready! ■

MEGAN.E.GALVIN@BOEING.COM

Mike Signora

HAS WORKED FOR BOEING:
16 years

TEAM:
Security & Fire Protection

LOCATION:
Philadelphia

PHOTO: FRED TROILO | BOEING

Starring role

North American's legendary B-25 Mitchell bomber turns 75

BY MICHAEL LOMBARDI

It was one of the most daring raids of World War II.

On April 18, 1942, just four months after the attack on Pearl Harbor, 16 B-25 bombers took off from the U.S. Navy aircraft carrier *Hornet* to attack the Japanese homeland. Named for its commander, Lt. Col. James "Jimmy" Doolittle, the Doolittle Raid over Tokyo and other cities in Japan did little damage to the industrial targets that were hit. But the effect on the national will of both countries was significant.

The raid gave a much needed morale boost to Americans in the wake of the painful blow inflicted on the U.S. Navy at Pearl Harbor, and it placed doubt in the minds of Japanese war planners.

It also marked the combat debut of North American Aviation's B-25 Mitchell, which would go on to be one of the most versatile, successful and produced medium bomber of the war.

The design of the B-25 began with the North American NA-40, a light bomber prototype that competed against the Douglas DB-7 (A-20). The NA-40 did not lead to a production contract but did serve as a basis for design studies that were initiated in March 1939 in response to the Army Air Corps wanting a medium bomber. In September 1939, North American, a Boeing heritage company, was awarded an initial order for 184 of the bombers, which had been named "Mitchell" in honor of Army Air Corps Gen. William "Billy" Mitchell, a military aviation pioneer and outspoken advocate for U.S. air power.

On Aug. 19, 1940, 75 years ago this month, pilot Vance Breese and co-pilot Roy Ferren took the B-25 up on its first flight.

Although designed to be a conventional level-flight bomber, the B-25 would go on to excel in the low-level attack role. U.S. Army Air Force Maj. "Pappy" Gunn and North American Aviation field service representative Jack Fox worked together to field-modify B-25s into a weapon that would be effective against enemy shipping and airfields, mounting multiple .50-caliber machine guns in the nose. The modification was so devastating to enemy shipping, in particular during the battle of the Bismarck Sea, that the concept made its way back to the North American factory, where engineers designed a production version designated B-25G. This model went a step further, with a 75 mm cannon, the same used on an M-4 Sherman tank.

Further modifications resulted in the B-25H, which had a lighter version of the 75 mm cannon and four .50-caliber guns in the nose as well as twin .50-caliber machine gun pods mounted on either side of the forward fuselage. Adding the firepower of the twin guns in the top turret, the B-25H had an accumulated forward firing power of a 75 mm cannon and 10 .50-caliber machine guns and four more guns in defensive positions. It was the most heavily armed airplane of World War II.

The next and final production version was the B-25J, which was built to fly both level-bombing and strafing roles that traded the difficult-to-aim 75 mm cannon for additional machine guns. It had a total of 14 forward-firing machine guns.

North American first produced the B-25 at the Los Angeles plant where all A through C models were built, as well as all G and H models. Ground was broken in March 1942 for a second B-25 assembly plant in Kansas City, where all B-25D and B-25J models were built.

The B-25 saw combat in every theater of World War II, from the South Pacific to Russia, and from the deserts of North Africa to the skies over Europe. They were operated by the air forces of America's allies, including Great Britain, Canada, Australia, the Netherlands, the Soviet Union and China. And 700 of the land-based bombers were acquired by the U.S. Navy.

In all, North American built 9,817 B-25s between 1940 and 1945. By the end of the war the Douglas A-26 Invader was replacing the B-25 as a medium attack bomber, but the B-25 continued to serve long after the war as VIP transports and training aircraft, many modified by Hughes Aircraft. They served with the U.S. Air Force until 1960. ■

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Illustration: (Above) A B-25H Mitchell bomber cutaway. **BOEING**

Photo: (Right) B-25Cs on North American's ramp at Mines Field (present-day Los Angeles International); following the Doolittle Raiders, these B-25s would be some of the first to see combat in World War II. **BOEING**


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Healthy options

Employees experience the rewards of good health in many ways

BY SUSAN D'ALEXANDER AND VICTORIA WIEDEL

Jeffrey Koellmer understands and appreciates the benefits of good health. After all, he's responsible for overseeing Boeing fitness centers.

But he and his wife also are raising three boys who are active in sports, and keeping them healthy is important, too, because medical costs can quickly add up.

Koellmer, an Enterprise Services manager in Everett, Wash., was among thousands of Boeing employees who enrolled in the Preferred Partnership medical plan for 2015.

The new plan has lowered their medical costs, according to Koellmer, a 23-year employee of the Shared Services Group. The benefits really hit home, he said, when two of his boys were sick with early-onset pneumonia and a sinus infection.

"The doctor's office said we no longer had to pay the $40 copay," said Koellmer, referring to the copay required under his previous health care plan. "Then we went to the pharmacy we always go to and picked up two sets of antibiotics, and there was no copay. We paid nothing between the doctor's office and the pharmacy."

First offered in the Puget Sound area of Washington state, Boeing plans to introduce the Preferred Partnership option in Charleston, S.C., and the St. Louis area for 2016, with other markets planned in the future. Eligible employees will be able to select the Preferred Partnership plan during this year's annual enrollment in the fall.

The Preferred Partnership plan provides lower paycheck contributions, no office-visit copayments for primary care physician visits, and generic prescription drugs covered at 100 percent.

The Preferred Partnership's "concierge service" model offers after-hours care availability and more personalized, coordinated care for complex medical conditions such as diabetes and heart conditions. Eligible employees in the Advantage+ health plan receive an increased company contribution to their Health Savings Account.

"We know many employees want to take steps to get and stay healthy, and to take charge when it comes to managing their health care costs," said Pam French, vice president of

The Step by Step Program is a voluntary, enterprisewide initiative that encourages employees to take control of their health. As a new part of Step 3 this year, Boeing is rewarding most nonunion and select union employees who participate in Steps 1 and 2. After completing a screening and the health assessment, some employees will have an opportunity to earn the $100 Healthy You Reward if certain criteria are met.

Step 1

Know your health numbers by participating in a screening.

Step 2

Prioritize your health risks by completing a health assessment.

Step 3

Take action to address any health risks and get rewarded.*

Compensation and Benefits. “That’s why Boeing provides employees with industry-leading health care benefits, including initiatives like Preferred Partnership, and offers well-being programs.”

Taking responsibility for one’s physical health goes beyond visiting the doctor and picking up prescriptions.

For Charmon Odle, the results of an on-site health screening appointment in 2011 prompted her to take action.

“I know what good shape looks like and feels like, and I was not in good shape,” said Odle, a former college athlete. Odle’s personal physician prescribed three medications during a follow-up visit after the screening. But she did not want to spend the rest of her life on medication.

Odle credits well-being resources provided by Boeing, including on-site screenings, the health assessment, WebMD Health Coaching and Boeing on the Move, with making her more aware of her situation and providing her with options to set and achieve personal health goals.

As an Integrated AeroStructures production and service quality manager in Auburn, Wash., Odle is used to forming and following plans to achieve goals.

“Unless you have a plan, at work and in life, it’s really difficult to accomplish your goals,” Odle said. A health coach helped her set the goal of running her first 5K, and she now schedules a running race each month and follows a training plan to ensure she crosses each finish line.

Odle lost a significant amount of weight and no longer has to take the medications prescribed to her after the screening. She has completed seven half-marathons, plus many shorter races.

“I definitely have more energy,” she said. “With exercise, I sleep better. My clothes fit better and I’m just more active.” ■

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*Although participation in the Step by Step Program is voluntary, some employees will pay more for medical coverage if they and their covered spouse or domestic partner do not participate. The Healthy You Reward is separate from and in addition to any medical plan contribution savings realized. Visit TotalAccess this fall for details.


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what a drag

Go behind the scenes as Boeing takes its ecoDemonstrator to Louisiana—and gets the bugs out

BY DAN RALEY | PHOTOS BY BOB FERGUSON

Bugs were an issue for Boeing, but exterminators and repellents weren't the solution. Rather than have a pest infestation removed, aerodynamics engineers Doug Christensen and Tom Farrell went looking for a nasty swarm of insects—the bigger, the better.

They wanted to fly the ecoDemonstrator 757 repeatedly into the heaviest concentration of flies, bees and mosquitoes they could find in order to come up with ways to design future airplane wings that are more bug-splatter-resistant—making the airplane more fuel-efficient. They first had to decide where.

With help from one of the country's leading entomologists, a team of Boeing employees, NASA personnel and others settled on Shreveport, La. The Southern city had everything—an airport with grassy areas, a neighboring bayou swamp and thick humidity—making it the perfect insect

Photos: (Left) Lynn Kimsey, University of California–Davis entomology professor, pursues a bug sample during Boeing testing in Shreveport, La. (Above) Twelve different insects, including a crane fly like this one, were detected on the wings of the ecoDemonstrator 757 during Boeing bug testing in Louisiana.


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breeding ground and test site.

"It was all about the bugs," said Christensen, ecoDemonstrator 757 program manager, Commercial Airplanes Development. "Were they going to show up when we were there? They definitely showed up."

At Shreveport Regional Airport, the right, or starboard, wing of the 757, wearing experimental coatings applied by NASA, registered a weighty 40,000 insect hits during 83 flights over 10 days. It didn't look much different from a motor home after a vacation, collecting all sorts of streaks, smears and skeletal bug remains.

While it might seem like no more than a messy inconvenience, a jet wing splattered at lower altitudes will disrupt smooth flow of air over the contour of the wings for the rest of the flight, with minuscule bug debris, dirt or even a scratch creating drag and extra fuel consumption, Christensen said.

What the ecoDemonstrator 757 team learned in Louisiana is that the usual bug buildup can be prevented to varying degrees, potentially leading to a significant savings in fuel consumption on a long-range flight, according to Christensen.

Boeing engineers experimented with a wing high-lift device, called a variable camber Krueger flap that unfolds from the underside of the wing, using it as an impromptu bug shield in different positions on the 757's left, or port-side, wing. These customized Krueger flap angles were responsible for a significant reduction in insect splatter on the wing's leading edge, which was a breakthrough.

"All of the focus might have been on the bugs, but these tests validated leading-edge technology on the wing as well," Farrell said. "That was the fun part."

Working independently, a 10-person NASA team applied and monitored five different coatings on the 757's starboard wing to see if it would limit bug contamination and airflow disruption. The aerospace agency, which eventually will share its test results publicly, found one of the treated layers resulted in a 40 percent decrease in splatter debris.

In previous testing in Hampton, Va., NASA researchers had used a "bug gun" to shoot crickets and fruit flies at stationary surfaces, firing just inches away to ensure full impact. In Shreveport, they introduced surface roughness and different chemicals to a wing typically moving at 150 mph (240 kilometers per hour) on low-altitude flights, and determined a combination of the two approaches worked best.

"The reduction is 40 percent, not 100 percent, so there's still something we don't understand to prevent bugs from sticking at those speeds," said Mia Siochi, NASA research materials engineer. "But 40 percent is still a significant number."

Lynn Kimsey, University of

Photos: (Clockwise from top left) Boeing product development engineers Jeff Burton, left, and Sabre Hecht inspect a removable wing panel for bugs; Alex Mulbah, flight-test engineer, enters data on a laptop while seated on the ecoDemonstrator 757; more than 40,000 bugs, including a paper wasp like this one, splattered onto the 757's right wing during testing; following bug testing, the ecoDemonstrator 757 was retired and is being recycled.

California–Davis entomology professor, has been at the center of Boeing's wing-debugging efforts since the outset. She took an active role in the test site selection and provided specialized knowledge whenever species questions arose. She came to Shreveport equipped with a butterfly net.

Her expertise has been in great demand since she helped the FBI solve a high-profile murder case. She identified splattered insect parts on a vehicle that had crossed over state lines, enabling investigators to determine where a suspect had traveled.

"I'm the queen of the bug splatter," Kimsey said.

Boeing initially considered 90 airport sites for bug testing, pared the list to a dozen, and visited two each in California, Florida and Louisiana before settling on Shreveport. Florida was ruled out because it imports bugs to pollinate its trees and the team didn't want to do anything to hamper those efforts. The state also was found to have too much rainfall, which would have washed away insect parts and delayed flight testing.

Kimsey suggested the Gulf Coast region, but the consensus opinion was the test site had to be inland to avoid windy conditions. Bugs can't fly in more than 10 knots (about 11 mph, or 19 kilometers per hour). Shreveport provided just the right geographical buffer, plus an airport that wasn't too busy with commercial flights, permitting the 757 to stay on course with its 83 landings and takeoffs.

Two cameras equipped with 300 mm lenses and mounted inside the plane snapped 180,000 photos, or one per second. A majority of the bugs hit the wings at 3,000 feet (915 meters) above ground level, and lower. Twelve varieties of insects were detected, among them chironomid midge, lovebug, acalypterate fly, dolichopid fly, honey bee, white butterfly, mosquito and thrip.

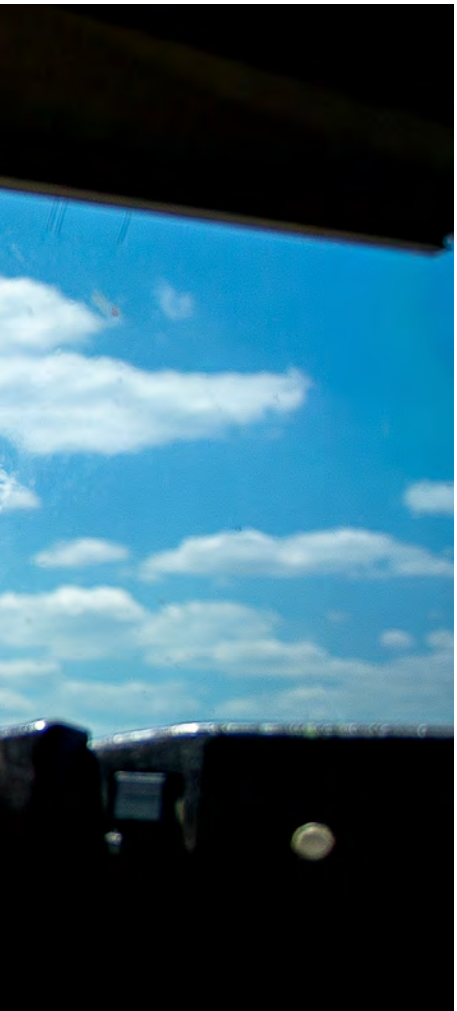
"The flower fly was the dominant insect that I collected," Kimsey said. "It left a big yellow and black splat."

NASA meticulously listed the types of bug residue left on the airplane wings, identifying whether it was insect wings, eyes or eggs because of the different compositions of matter. Splats also were examined for size and color. Bug residue hardened if it was left on the surface too long. Wings were cleaned after each flight with a sponge and water.

Eighty-eight wing panels resembling oversized piano keys were coated in some manner, some only partially. More than 70 of them were removed and shipped to NASA in Virginia for further testing.

A Shreveport test flight lasted no more than 10 minutes and usually topped out between 5,000 and 10,000 feet (1,500 and 3,000 meters). Everything became fairly routine in the bug-filled skies.

Following Shreveport, the 757 conducted additional wing testing in Sacramento, Calif., and Seattle before the jetliner was removed from service,



which was the plan all along. As part of Boeing's ecoDemonstrator program, which is an effort to accelerate testing, refinement and use of new technologies and methods that can improve aviation's environmental performance, this aging plane has been decommissioned and much of it is being recycled. In collaboration with the Europe-based tourism company TUI Group, the 757 was the third plane designated as an ecoDemonstrator, joining an American Airlines 737-800 in 2012 and a company-owned 787 Dreamliner last year.

As is often the case in product development, information gleaned from the 757's trip to the South will continue to be refined, Christensen said. Some version of these technologies might not be utilized for another decade, or until the next new airplane is designed.

Shreveport provided an ideal location for Boeing testing, supplying researchers with more than enough bugs to analyze. In fact, it was too many, according to Christensen. After storing equipment on the ground at the Louisiana airport for a week and a half, and reloading it on the jet, team members found the 757 filled with stowaway chiggers, or mites.

Ironically, Boeing's bug testers needed outside assistance before they could leave. They had to hire a local exterminator.

"We had to close up the airplane and set off bug repellent inside," Christensen said. ■

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Photos: (From top) Mia Siochi, left, NASA research materials engineer, and Mary Sutanto, Boeing aerodynamics engineer, examine bug splattering during Shreveport testing; Al Gibson, flight-test mechanic, cleans the windshield of the ecoDemonstrator 757.

BAD to th

Boeing upgrades the supersonic B-1 bomber for the tough missions of today—and tomorrow

BY BEN DAVIS

In a triple-wide hangar on the edge of the runway at Dyess Air Force Base in Abilene, Texas, Terry Kemper prepares to enter an empty fuel cell in a B-1B bomber. In order to reach it, he must crawl through two access holes only 15 inches wide by 20 inches high (38 by 51 centimeters).

"To get to the fuel cell where we are replacing the wall, we remove a panel, crawl through, remove a second panel and enter the fuel cell," explained Kemper, who is just over 6 feet (1.8 meters) tall and certified to safely work in enclosed spaces. "I have to get one arm and shoulder in, then pull the other through. For the second hole, I tuck up in the fetal position and go in feet first."

Kemper is a member of Boeing's B-1 bomber Contract Field Team, a group of 20 or so technicians who

ne BONE

Photo: B-1 bombers of the 337th Test and Evaluation Squadron, based at Dyess Air Force Base in Abilene, Texas, refuel from a KC-135 tanker. **JIM HASELTINE | HIGH-G PRODUCTIONS**

perform a variety of repair projects on the nation's only supersonic bomber.

"The space is so small we have to cut the wall in half and send it out in two pieces. It can get a little cramped in there," he said. "It's funny, because when I served in the military, we worked on this same area but only did a temporary fix. Now I'm on the other side, replacing it to extend the life of the aircraft."

As the B-1 bomber enters its fourth decade of service with the U.S. Air Force, Boeing employees across the country are developing and installing several upgrades that keep the "Bone" (B-one) on the cutting edge of performance. From wings to wiring, the aircraft is undergoing a thorough modernization. Just as Kemper has learned to adapt his size and frame to the space required, so the B-1 continues to adapt to an ever-changing battlefield.

Most recently, it has seen extensive action in Operation Inherent Resolve, the campaign against the Islamic State group of militants in Iraq and Syria.

For several months starting last year, B-1s from an air base in Southwest Asia have pounded ISIS targets in and around the Syrian city of Kobani, near the Turkish border, which had been overrun by the militants. The bombing campaign is credited with helping Kurdish allies retake the city.

Before that, the B-1 was a workhorse in Afghanistan and Iraq. Originally developed as a nuclear strike bomber by Rockwell, a Boeing heritage company, it was transformed to carry conventional weapons with the end of the Cold War. Indeed, the B-1 can carry many more bombs and missiles than any other aircraft in the U.S. inventory. The bomber has a crew of four, with wings that sweep back in flight for high speed (top speed is more than 900 mph, or 1,480 kilometers per hour).

Other than when deployed to forward bases, the bombers are based at Dyess and Ellsworth Air Force Base in South Dakota. The fleet of 62 aircraft is scheduled to receive cockpit and systems upgrades through the end of 2019.

Three hundred miles (480 kilometers) from Dyess, in Boeing's Oklahoma City office, software engineer Leah Morales scans lines of code on a computer screen, looking for errors. Morales is test lead for Central Integrated Test System (CITS) for the B-1, a system that monitors the technology on board the aircraft for errors.

"The purpose of CITS is to detect any problems as soon as they occur," Morales explained. "The software is always running, detecting fault codes so we can fix any issues that come up. Just last week our program detected a hot

air leak near the wheel well of the B-1. Our software was able to detect it and prevent damage to the landing gear."

Morales and others on her team must run simulation after simulation to refine the software so it performs perfectly once installed.

"We test CITS in the lab and also on the plane because it has to perform in the real world. I like trying to break it, to break our code. If I can't break it, I know we've done a good job," she said.

CITS is one of three major technology upgrades that are modernizing the B-1. Fully Integrated Data Link updates the data link on the aircraft, while the Vertical Situation Display Unit replaces monochrome pilot and co-pilot displays with digital screens—the so-called glass cockpit. Collectively, all three updates are known as the Integrated Battle Station.

By bundling three modifications into one effort, Boeing's team improves vintage 1970s and '80s software and computing capabilities throughout the entire aircraft. Some aspects of Integrated Battle Station are immediately obvious—each crew member now has a full-color, digital display screen in place of analog dials—while other improvements manifest themselves in operations.

"With Integrated Battle Station, the radar command doesn't require lots of buttons, just one button. With the updated user interface, you can engage targets using the radar or targeting pod with a single cursor control switch hit," said Tom Adolfs, a B-1 software engineer.

Adolfs, like Morales, has spent years developing and testing the software now being deployed on the B-1 fleet. The goal isn't simply to add a digital sheen to the bomber, he said, but rather

Photos: (Clockwise from top left) Leah Morales, foreground, software engineer, and Associate Technical Fellow Devron Hanks inspect wiring layouts inside the B-1 bomber as part of the Integrated Battle Station upgrade; Boeing's B-1 bomber enters its fourth decade of service with the U.S. Air Force with modernized cockpits, software and capabilities; Dedric Lary, left, Maintenance and Repair specialist, and contractor John Caswell inspect the B-1 bomber's lower wing skin for cracks or indications of stress. **BOB FERGUSON | BOEING**

increase its effectiveness and efficiency for the men and women who fly it.

"Our designs have reduced the workload on the crews and increased situational awareness. We reach out and communicate with crew members to help us think like them so we design products that truly meet their needs," he said.

All of this effort begs a question—why update 30-year-old platforms like the B-1, particularly in light of the upcoming Long Range Strike Bomber program.

"The B-1 has decades of structural life ahead of it, and it is a platform that has and continues to adapt to our military's needs. And not just adapt to changing environments, but really excel in them," said Rick Greenwell, B-1 program director.

From his office in Oklahoma City, Greenwell can see the runway on Tinker Air Force Base where B-1s land for maintenance that includes Integrated Battle Station installation.

"When you look at the history of this aircraft, it started off as a nuclear-capable Cold War deterrent," Greenwell

said. “Well, the Cold War ended. So then what? We worked with the customer to evaluate their needs, and we modified the B-1 to only carry conventional weapons. When the wars in Afghanistan and Iraq started, the B-1 took on a close air support role. We supported that new role through some specific modifications and now, when you look at current missions, the B-1 has become the workhorse of the U.S. Air Force.”

B-1 crews with the 9th Expeditionary Bomb Squadron in 2014 dropped more than 2,000 precision-guided bombs in six months—a record—in support of troops engaged in Operation Inherent Resolve, according to the U.S. Air Force.

“It’s the adaptability of the jet that really is what has ensured its relevance—not only from the early 1990s to today but from today well into the future,” said Col. Jason Combs, 7th Operations Wing Commander at Dyess.

Even with the new Long Range Strike Bomber slated to join the current U.S. Air Force mix of B-1, B-2 and B-52 bombers, it may take most of a decade before it will fully deploy alongside its siblings. Boeing’s current work on the B-1 ensures the bomber can soar through at least 2040, according to Greenwell.

“Ultimately the customer will decide when or how long any of the bombers will fly, but the B-1 will be a top performer for decades to come,” Greenwell said.

Meanwhile, for Boeing’s B-1 team, the sum total of the Bone’s value is greater than each individual capability.

Back at Dyess Air Force Base, Contract Field Team member Steven “Paco” Olivas performs quality assurance for all of the repair programs—among them, wing structural inspections and repairs and a navigation enhancement called Inertial Navigation System Replacement.

In his years at Boeing combined with a long military career, Olivas has logged more than 20 years of working on the B-1.

“At first, repairs were challenging, especially compared with the F-15 where I used to work,” he said. “The scope of the repairs in ’93 when I started on B-1 was huge and intimidating. But I learned to love this aircraft. You put your heart and soul into it and you start to see how graceful it is in the air, how responsive.”

Olivas lives under the flight path of planes coming to the base, and he can hear the distinctive roar of the B-1’s four powerful engines.

“Sometimes I look up and enjoy watching them fly over,” Olivas said. “The B-1 really delivers. It lives up to its promise.” ■

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View a video about the B-1 bomber at boeing.com/frontiers/videos/august.

Photos: (Clockwise from top left) A B-1 streaks high above Kobani, Syria. **GETTY IMAGES** A co-pilot’s view of the B-1’s new digital cockpit display. **JIM HASELTINE | HIGH-G PRODUCTIONS** James Webster, B-1 repair technician, inspects a section of the bomber’s forward fuselage. **BOB FERGUSON | BOEING**


BOEING

Fantastic four

F/A-18s and F-15s on the flight ramp at the St. Louis jet fighter factory recently were joined by visiting advanced Apache and Chinook helicopters, offering the rare opportunity to capture four of Boeing's latest military products in one image. The Chinook is built in Philadelphia; the Apache in Mesa, Ariz. From left: an F/A-18F Super Hornet, CH-47F Chinook, AH-64E Apache and Advanced F-15 air superiority fighter. To download a poster of this image, visit boeing.com/frontiers/downloads. **PHOTO: RON BOOKOUT | BOEING**

SEE CHANGE

Boeing's patented simulation technology provides military pilots the most realistic view possible without being airborne

BY KATIE PERDARIS

Lt. Col. Tom Isenberg, a fighter pilot in the Air National Guard, is at Bagram Air Base in Afghanistan when the emergency call comes in and the unit's jets are scrambled. Friendly troops are being overrun, and the pilots need to be airborne quickly to provide close-air support. Isenberg's F-16 is soon in the air and he is able to make radio contact with a ground controller, who provides coordinates on where the enemy forces are. Isenberg heads in that direction, spots the enemy and swoops in low, laying down ordnance and allowing the friendly troops to safely disengage. Mission complete, he returns to base, physically and mentally tested.

Only in this case, the "base" is a training center and he is flying in a simulator, one equipped with Boeing's Constant Resolution Visual System, or CRVS.

"It's as realistic as you can get without the other sensory inputs from actually flying—the acceleration, the G-forces, the noise," Isenberg said of the CRVS, a patented technology that has set Boeing apart from its competitors.

Isenberg, who works in Global Sales & Marketing for Boeing Defense, Space

Photo: Eric Hauquitz, left, lead systems engineer for the Constant Resolution Visual System (CRVS), guides a pilot as he trains using the CRVS. **BOB FERGUSON | BOEING**

& Security, is also an F-16 pilot in the Alabama Air National Guard. In April 2014, his unit was deployed to Afghanistan for six months and often provided close-air support for ground troops. The hours spent training in a CRVS simulator, and "flying" the above kind of scenario, Isenberg said, helped him and other pilots prepare for those lifesaving missions.

Unlike traditional visual systems that use flat screens to cobble together a 360-degree display, the CRVS uses long curved screens to present a much more natural and realistic constant-resolution display—one where all pixels are the same size to the viewer, said Eric Hauquitz, lead systems engineer in St. Louis for the CRVS.

With a flat-screen visual system, he said, the corners have higher resolution and the middle has lower resolution. The CRVS provides the same resolution in every part of the screen.

"In the real world everything we see is constant resolution," Hauquitz explained. "The shape of the system capitalizes on our natural field-of-view and focal length, giving the user a better feel of depth and less eye fatigue since our eyes aren't having to constantly focus at different distances."

The smooth flow of the screen structure provides the cues necessary for the brain to become fully immersed in the simulation, he said. The patented curved shape of the screens, combined with Boeing's screen coating, are what creates the constant resolution.

The focal length, or distance from the eyes to the screen, only varies about 8 inches (20 centimeters) from the bottom of the visual system to the top, replicating the brain's natural assumption that things higher up are farther away, Hauquitz said.

"It makes what we see more like the real world," he said.

Hauquitz and his team spent many hours troubleshooting to create the perfect combination of the image generator, screens and projectors to get a clear, razor-sharp image. Even the mirrors that the images bounce off of and onto the screen are satellite-quality, ground and polished.

"We have an exceptional team of professionals that have spent the past few years bringing the CRVS to life, from the initial conceptual drawing to the finished product," Hauquitz said. "We all take personal responsibility for the performance of the system and are proud of it."

Unlike legacy training systems, the CRVS was designed for high-definition format projectors, and the wide-screen coverage means almost every pixel in the projectors are used, Hauquitz said. This produces a crisper image, providing pilots with a more realistic training experience.

Isenberg said there is no comparison between CRVS and legacy simulation technology.

"With a visual system like CRVS, you really become part of that environment," he said. "That is a very important part of the training piece—tricking your brain into those stressful situations that feel like you're absolutely there, and thinking 'that looks so real, if I hit that other airplane, I'm going to die.'"

Boeing delivered the first CRVS displays in 2010 to the U.S. Air Force. Since then, they have been installed on a variety of simulator platforms, including Boeing's AH-64 Apache attack helicopter and F-15 jet, as well as BAE's Hawk and Lockheed Martin's F-22 Raptor and F-16 jets.

Customer feedback, Hauquitz said, has been "ecstatic."

The CRVS' visual acuity, or image clarity, is based on the resolution of the projectors. While the CRVS will work with the majority of high-definition projectors on the market, Boeing's baseline offering uses a projector that gives the user 20/40 visual acuity. Through an exclusive agreement with JVC, Boeing also offers a higher-resolution projector that

Photo: A pilot trains for a refueling mission in an F-15C simulator equipped with the CRVS. **RICH RAU | BOEING**

provides the user 20/25 visual acuity.

"We use the same eye charts that ophthalmologists do," Hauquitz said, explaining how visual acuity is measured with the CRVS. On eye charts, 20/20 vision is considered perfect. What looks 20 feet (6 meters) away is 20 feet away. If someone has 20/25 vision, it means something that 20 feet away appears as if it were 25 feet (7.5 meters) away.

The capability of the CRVS to give pilots visual simulator acuity of 20/25 or even 20/40 is significant for their training, said Hauquitz, a U.S. Army veteran.

"The team knows that our simulators are providing the warfighter the best training available, and as a veteran that means a lot to me," Hauquitz said. "The closer we can get to real life, the better. We need pilots who can react on instinct, and not have to think. If we can put them in a situation in a simulator that's going to train them to use their instinct, that's going to make them better pilots."

Isenberg agreed.

Having spent a lot of time training in legacy simulator systems, Isenberg said there are many tactics pilots can now train for using the CRVS that they weren't able to before, such as formation flying and air-to-air refueling. Training for night vision is also enhanced. To train for night flying on a legacy system, pilots wear goggles that simulate night using a projected image. With the CRVS, pilots fly with actual night-vision goggles and the system stimulates the goggles to create a night scene.

"The realism that goes with that is second to none," Isenberg said. "It's important to train for night to learn how limited the field-of-view is, and how cues such as line of sight and closure are degraded at night."

Isenberg doesn't believe training in simulators will ever fully replace the experience of actually flying in an aircraft, but he said a simulator does provide pilots the opportunity to practice routine tasks and hone their skills in an environment that can't always be replicated in an aircraft, at a significantly reduced cost compared to actual flight time.

"I'll go for a week to the mission training centers," he said, "and those missions become so advanced by the end of the week that once you go back to flying the aircraft, you feel like you can take on the world—because you've just been through the gauntlet in the sim, in an environment that felt so real."

The capabilities and realism of CRVS also means pilots can practice against the next-generation of enemy fighters that don't yet exist, he said, and prepare for the kinds of threats those aircraft would present.

"We have to rely on better training systems in order to practice against these advanced threats," Isenberg said. "The CRVS takes training to another level, complementing the realism that you get from these really high-fidelity cockpits and introducing those advanced threats that we don't have assets to replicate in the real world."

So what's next for the visual system?

Hauquitz said Boeing is continuing to develop the CRVS.

"By the time you get to 20/25, you're real world," Hauquitz said. "Next we'll bring in motion, and other technology that the jets have. If we can do that, we can take a lot of danger out of the sky, so it's a lot safer when pilots are in flight." ■

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Photo: An Apache pilot prepares for a training mission in the Apache Longbow Crew Trainer with CRVS. **RON BOOKOUT | BOEING**

Nonstop excellence

American Airlines opens new routes with the 787 Dreamliner

BY DOUG ALDER

With rain falling on a chilly afternoon this past January at Paine Field in Everett, Wash., David Hensley anxiously paced around a brand-new 787. A test pilot for American Airlines, he was preparing to take the airplane for its first customer acceptance flight.

"We'd really like to take it up for a ride today," Hensley said.

With daylight fading, Hensley got the green light and became the airline's first employee to fly its Dreamliner—a highly efficient airplane that's already opening up new routes and opportunities for American.

"It was very, very quiet," said Hensley after the flight. "I think our pilots are really going to enjoy the airplane."

More important, American says it wants customers to enjoy the 787 and the new routes the airplane is opening. As a key part of its fleet renewal plan, American recently launched 787 service from Dallas/Fort Worth International Airport to Beijing and Buenos Aires. And later this fall, American will start using the Dreamliner from Los Angeles International to Shanghai and São Paulo.

"American's goal is to become the greatest airline in the world, and we know they're counting on the 787 to help them get there," said Brad McMullen, Boeing's vice president for North America Sales.

Almost 600 Boeing airplanes are part of American's fleet, including Next-Generation 737s and 777s. But the advanced 787 required fresh, innovative approaches to maintain and fly, according to the carrier. So to help ensure a smooth entry into service for the 787, the airline sent a crew from Dallas/Fort Worth to the Puget Sound region to put the airplane through its paces prior to delivery.

"We sit in every seat and look at everything a customer might touch or use," said American flight attendant Joyce Adkins.

Boeing, in turn, shared its 787 best practices so the airline's team would be prepared once the fleet began arriving. American says that approach has proved successful. At the end of June, the airline saw six 787s join its fleet, with 36 still to come.

The next new Boeing jet that American will start prepping for is the 737 MAX. The airline has 100 of the single-aisle airplanes on order. But right now, the Dreamliner is stealing the spotlight.

"The 787 is something that will be written into our company's history," said test pilot Hensley after that first flight in January. "When I'm 70, I'll be telling my grandchildren about this." ■

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Photo: The first 787 for American Airlines takes off on a test flight at Paine Field in Everett, Wash., in January. GAIL HANUSA | BOEING

Trained to the

MAX

Employees master skills for final assembly of the first 737 MAX

BY LAUREN PENNING | PHOTOS BY BOB FERGUSON

Chris Leiker joined Boeing in February after years of working on small avionics equipment such as gyroscopes for the flight deck. Now he is looking forward to putting together something much bigger—Boeing's newest single-aisle airplane, the 737 MAX, which has started production and is scheduled to begin final assembly in Renton, Wash., later this year.

"When I got my training schedule it showed me on the 737 MAX and at the time I didn't even know about the airplane," Leiker said.

But that has changed during months of training that included classroom study, hands-on factory experience on the Next-Generation 737 and special skill drills in mock-ups that simulate the new-build areas of the 737 MAX. Now he not only knows the airplane; he knows he is part of something special.

"I feel incredibly fortunate to be part of this," Leiker said. "Building the first 737 MAX is a story that I'll share with my grandkids one day."

Leiker is one of several hundred mechanics who are mastering the skills required to build Boeing's most advanced single-aisle airplane, which promises a 14 percent fuel savings compared to today's Next-Generation 737. This improvement will come from the new LEAP-1B engine supplied by CFM International, but additional savings come from aerodynamic changes to the airplane itself, such as aft body reshaping, use of Advanced Technology winglets and new systems to support those changes.

These design innovations mean that, to be successful, even seasoned mechanics would need additional training.

"It took a lot of effort by the Operations team," said Ed Cranford, 737 MAX Operations manager responsible for the training plan. "We broke down the changes to the airplane and identified all the certification and skills practice each mechanic would need."

For example, fiber-optic data transmission has limited use on the Next-Generation 737, but the technology is needed for some new systems on the 737 MAX, such as supplying data to new large-screen flight-deck displays.

Creating teams with a mix of experience was another element in the training plan.

"When we started building the Next-Generation 737 we struggled at first," Cranford said, "because

Photo: Stuart Whiting, 737 MAX mechanic, practices installing wiring in a mock-up of the reshaped aft body of the 737 MAX.

the team was made up of mostly new employees." As a result of that experience, 80 percent of the first group of 737 MAX mechanics have two or more years of experience on the Next-Generation 737, so they already understand the 737 production system—and the safety culture.

Lee Foldesi has been an electrician on the 737 for four years. "My grandfather used to make the rivets that held the 737 together," Foldesi said. "Now I get to be part of something brand-new."

Preparing for the 737 MAX not only required building the right team with the right skills but also helping it foresee the inevitable problem areas. Working through the training, mechanics already have been able to identify potential issues before they became problems in the factory.

For example, during training Foldesi found a discrepancy between the engineering drawing and the wiring when he was practicing on a mock-up for the MAX. He was able to identify what needed to be changed and share that with the MAX Operations team to implement a fix. "Being able to identify and address those kinds of issues now will save time when the airplane is in the factory and is a huge advantage," Foldesi said.

Mechanics are being cross-trained to work multiple positions on the assembly

Photo: Chris Leiker, left, and Lee Foldesi train on a mock-up of the 737 MAX wheel well.

line to minimize downtime between airplanes as the first 737 MAXs ease their way into the flow. It's a change from the current routine, in which mechanics work the same position every shift in the fast-paced, 42-airplanes-a-month flow of the Next-Generation 737.

Stuart Whiting will be working in the last position on the production line, where mechanics test the systems and control surfaces of the airplane to ensure everything works properly. To improve efficiency, he also will install wiring at the beginning of assembly. "If something needs to be fixed down the line, we'll know where the wiring is located to quickly fix it," he said.

As production of the first 737 MAXs matures, the Operations team has a plan to slowly transfer employees working on Next-Generation 737 Final Assembly to the MAX so they can learn on the dedicated MAX production line. Toward the end of the decade, MAX production will supplant Next-Generation 737 production and all Renton mechanics will benefit from the knowledge developed by this pioneering team.

Foldesi said he anticipates there will be bumps in the road, as with any program. But "being part of the team that gets to devise ways to fix them for the people coming after—that is something that I want to be a part of." ■

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Advance

Boeing Australia is a model for the company's international business strategy

BY ASHLEY JOHNSON | PHOTOS BY TIM REINHART

When Boeing's ecoDemonstrator 787 took to the skies from Seattle last year, some of the innovation and technology tested on the airplane reached all the way to Fishermans Bend in Melbourne, Australia.

That's where Boeing Aerostructures Australia makes the movable control surfaces on the trailing edge of the composite wings of the 787 Dreamliner using a technology called resin infusion. And that's also where Boeing Australia's research division, working with Commercial Airplanes Product Development and Boeing Canada Winnipeg, applied lessons from that endeavor to use resin infusion for the

Photo: A view from Sydney Harbour showing the Sydney Opera House, left, and city skyline.

Australia

composite engine pylon aft fairing for the ecoDemonstrator 787.

With resin infusion, dry fiber is injected with resin in an oven using atmospheric pressure. The technology enables complex shapes and contours, and offers cost and weight savings over the traditional composite manufacturing process.

What had been a multiple-piece design for the pylon aft fairing became one piece, reducing the weight of the fairing by about 20 percent, with manufacturing cost savings of about 50 percent.

"That production difference allows us to have significantly reduced detailed part costs compared to the traditional means," said Mike Dickinson, managing director of Boeing Aerostructures Australia. "This is the only place within Boeing that we're currently manufacturing components using resin infusion and Fishermans Bend is a center of excellence for this technology."

The resin infusion technology is just one example of how Boeing Australia is helping sharpen the company's innovative edge. And it underscores how important Australia is to Boeing's global business—and future success.

"There is an innovative, entrepreneurial spirit in Australia, and we do our best to reflect that same spirit in our operations," said Maureen Dougherty, president of Boeing Australia and South Pacific. "Australia also loves aviation and aerospace, and Boeing has played and continues to play such an important role here."

With more than 3,000 employees across 27 sites, Boeing Australia has the company's largest footprint outside the United States. Its strong focus on commercial manufacturing, defense, and research and technology make it both a microcosm of U.S.

operations and a model for Boeing's international business strategy.

Marc Allen, president, Boeing International, pointed to Boeing Australia's relationships with nine universities, the Defence Science and Technology Organisation, and the Commonwealth Scientific and Industrial Research Organisation—Australia's national science agency—as key to development of technology that will enhance future Boeing products.

"Australia really put its national focus on research and technology, not just in aerospace but across other industries, and that investment by the nation in its university system, in its research systems, is what's created this really healthy ecosystem for us to participate in," Allen said.

Australia and the United States have a long-standing friendship and cultural ties, and Boeing has been a part of the country's rich aviation history. Douglas Aircraft, a Boeing heritage company, sold a DC-2 to Australia in 1936. Qantas, the country's flagship carrier, was the first international customer for Boeing's 707, in 1959. And the roots of Boeing Aerostructures Australia date to 1927, when the de Havilland Aircraft Co. established its first overseas subsidiary in Melbourne. The company was acquired by Boeing in 2000 and subsequently changed to Boeing Aerostructures Australia.

In addition to the movable trailing edges for the 787 wings, Boeing Aerostructures Australia makes ailerons for the 737, movable leading edges for the 747, and elevators

Photos: (From far left) Robots drill and fasten movable trailing edge components at the Melbourne 787 assembly line; Boeing employee Glen Bowman works on a C-17 tire at Royal Australian Air Force Base Amberley.

A slice of community

Learning math can be fun—especially when there's pizza involved.

As part of Boeing's Global Corporate Citizenship program, Boeing Australia employees in Melbourne and Brisbane partner with the Stephanie Alexander Kitchen Garden Foundation to put gardens in school playgrounds, develop textbook curricula, and educate students about where their food comes from and how to prepare it—and that's where the pizza comes in.

Dividing the dough and sauce allows students to grasp fractions in a fun way.

"They're learning about healthy eating, where the products and the produce come from, but reading a recipe also helps with literacy and their numerical skills as well," said Jo Barron, lead for Global Corporate Citizenship for Boeing Australia.

While fostering science, technology, engineering and math (STEM) interest among youth is a major focus of Boeing Australia's outreach, the company also strengthens the community by supporting efforts to sustain the environment and help veterans.

Boeing Global Corporate Citizenship supports the Great Barrier Reef Foundation, which trains and equips citizen scientists for data collection to monitor and protect the health of the iconic coral reef.

As part of a long-standing partnership with the Australian War Memorial, Boeing is supporting a civic engagement project to educate kids and adults about the country's involvement in the Afghanistan conflict. And in partnership with Sydney's Taronga Zoo, Global Corporate Citizenship funds an outreach program where zookeepers take animals to rural areas, disadvantaged communities, and long-term care facilities for veterans and the elderly, giving people who can't get to the zoo an opportunity to learn about the environment and enjoy Australia's indigenous wildlife. ■

and rudders for the 777.

Many of the parts and assemblies manufactured by Boeing Aerostructures Australia are on Boeing jets flown by the country's airlines. Qantas operates 75 Next-Generation 737s and its low-cost subsidiary, Jetstar, soon will have an all-787 fleet for international routes. Virgin Australia Airlines, part of the Virgin Group, has a large fleet of 737s and was the first airline in the region to order the 737 MAX.

The 737, which can fly for up to six hours with a range of more than 3,000 nautical miles (3,500 miles, or 5,600 kilometers), "is a great workhorse for the region and you see lots of 737s flying to and from Australia," said Dinesh Keskar, senior vice president, Asia-Pacific and India Sales for Commercial Airplanes.

Sydney Airport also is an international hub, with Boeing jets from all over the world flying in and out of the airport on Australia's east coast. Air New Zealand, flagship carrier of Australian neighbor New Zealand, was the launch customer for the longer 787-9 and has several of the airplanes.

The 787-9 and the new 777X now in development will be attractive for this growing region because they offer significant fuel efficiency and range, and profitability for the airlines, according to Keskar.

Along with strong commercial prospects, Boeing has a robust defense business in Australia. Boeing Defence Australia, a Brisbane-based subsidiary of Boeing Defense, Space & Security, is a major supplier to Australia's military. It's also home to advanced modeling, simulation and prototyping capabilities from Phantom Works.

The Australian Defence Force is the only customer, other than the U.S. Navy, for Boeing's EA-18 Growler, the electronic warfare version of its F/A-18 Super Hornet. Australia also was the first international Super Hornet customer. That shows the strength of the relationship between the two countries, said Syd Blocher, director of Business Development in Australia for Boeing Defense, Space & Security.

The first of Australia's 12 Growlers is expected to be delivered in 2017.

The Growler will fit right in with the Australian Defence Force's mix of Boeing aircraft and products, which includes the C-17 Globemaster III, the Wedgetail Airborne Early Warning & Control aircraft, the CH-47 Chinook helicopter (including the latest "F" model), Harpoon missiles, Joint Direct Attack Munitions, and command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) systems.

And the Australian government, in February 2014, approved the acquisition of eight P-8A maritime patrol and surveillance aircraft based on the 737, with the first to be delivered in 2017.

As Boeing's C-17 production in Long Beach, Calif., wound down this spring, the Australian government announced it would acquire two more of the aircraft, bringing its total to eight. In addition to the C-17's military capabilities, Australia uses it as a "tool of friendship and diplomacy," Blocher said, citing the country's deployment of C-17s to provide humanitarian aid following a cyclone on the South Pacific island of Vanuatu and earthquake in Nepal.

Australia plays an important role regionally and globally, Blocher noted, adding: "It's a point of pride that we are right there with them as a company to support their operations."

Boeing Defence Australia's recent successes are part of a journey that included early setbacks with Boeing's Wedgetail program. The first of the 737-based aircraft was delivered about three years late. But Australia now has all six of its Wedgetails, and they are performing well, according to the Royal Australian Air Force.

"We stood behind what our

Photos: (From top) Boeing Aerostructures Australia employee Shivakumar Lingaiah assembles a 787 inboard flap; Qantas 737s lined up at Sydney Airport.

commitments were and we got it right and we delivered Wedgetail through an enormous amount of work on both sides of the Pacific," said Kim Gillis, who leads Boeing Defence Australia. Gillis pointed out that Boeing Defence Australia is now the prime contractor on a significant sustainment contract for Wedgetail, which further underscores the strength and trust in the relationship.

Australia also is an important partner in research and development. Boeing Research & Technology–Australia was established in 2008 and is the largest of Boeing's six international research centers, specializing in composite materials development and processing; unmanned aircraft systems; aircraft maintenance and training support systems; robotics; and network solutions. The Australian team spearheaded the resin infusion technology used on the ecoDemonstrator 787.

Another area of focus for Boeing Australia's research team is the application of light robotics for manufacturing and repair automation, which saves time and reduces ergonomic risks for employees, said Michael Edwards, general manager of Boeing Research & Technology–Australia. Robots already are performing in-factory composite repairs, and researchers are looking at using small, portable robots to perform in-service repairs on airplanes in the field.

About 40 employees with the Boeing research center in Australia work with the more than 1,200 employees at Boeing Aerostructures Australia in Melbourne. Likewise, about 20 researchers are on-site with Boeing Defence Australia, focused on human factors, unmanned systems, and

modeling and simulation research.

"It's a fantastic system that helps us get our current production costs lower as we learn," explained Dickinson, the managing director of Boeing Aerostructures Australia. "It helps us design better on the next airplane, and it helps us focus our research in the areas that provide the biggest opportunities."

The partnership allows employees to move back and forth between the research organization and Boeing Aerostructures Australia, he said, providing flexibility for the business to accommodate changes in work demands and creating development opportunities for employees.

Edwards added that this partnership is an advantage that springs from the open and collaborative culture at Boeing Research & Technology–Australia.

"We want and, in fact, very deliberately build that culture around mixing the different disciplines of the team with one another so it's not just chemists working together or structural engineers working together or robotics engineers working together," Edwards said. "They're all actually working on solutions with all that different expertise coming together as one."

That philosophy also helps explain the success of Boeing Australia. ■

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Photos: (From far left) Boeing Aerostructures Australia 787 operators Ryland Robinson, foreground, Aiden Pears, middle, and Clifford Parks inspect a 787 flap jig; Boeing employees work on the Airborne Early Warning & Control aircraft at Royal Australian Air Force Base Amberley.

A higher orbit

Satellite designer Harold Rosen had an idea for global communication and changed the world

BY DAN RALEY

As Boeing approaches the start of its second century in July 2016, *Frontiers* takes a look at some of the men and women who helped make Boeing a global leader in aerospace. This series highlights the innovation, skill and courage needed when daring to do the impossible.

Harold Rosen was told that his newly designed geostationary satellite wouldn't work. Other scientists called it onerous, impractical and unreliable. And for a short time they were right. Syncom I was lost during launch in 1963.

Rosen, however, was determined to respond to the Soviet Union and its first-in-space Sputnik satellite, to make inroads, to quell his critics. Working for Boeing heritage company Hughes Aircraft, he and his team changed the motor, wiring and nitrogen-tank pressure. Five months following that initial setback, Syncom II was put into orbit and worked perfectly.

This enabled President John F. Kennedy to call Nigerian Prime Minister Abubakar Balewa from the White House, marking the first two-way satellite telephone call between heads of state. And with Syncom II and newly launched Syncom III linking up, the 1964 Summer Olympic Games in Tokyo were broadcast on TV live to the United States in black and white.

Rosen brought the world closer together. Cellular phones, emails and unlimited cable TV channels all were eventual benefits of his vision for communications satellites in geostationary orbits, where they remain at fixed points above Earth. Global communications would never be the same again.

"One of the reasons I was interested in communications for application to space was the sad state of long-distance communications at the time," Rosen recalled in an interview. "Telephone service between the U.S. and Europe was expensive and hard to come by; you had to basically put in a reservation just to put in a telephone call. Transoceanic TV was impossible.

"There was a lot to be gained by having a satellite system—I still believe this has been the single most important service provided by space."

Rosen, who lives in Pacific Palisades, Calif., with his wife, still drops by his office at Boeing's satellite factory in nearby El Segundo, where Hughes Aircraft, the company founded by Howard Hughes, once made its satellites. Rosen went to work at Hughes in 1956.

As Boeing prepares to celebrate its centennial, Rosen is among the many men and women who have made milestone contributions to Boeing and its heritage companies. More than five decades after his initial success, the man known as the father of the geostationary satellite still holds considerable influence in his industry. And he lends his expertise to problem-solving on occasion.

A few years ago, two Boeing-built satellites weren't functioning properly as they orbited 23,000 miles (37,000 kilometers) away in space. Retro-rocket separation had left lead deposits on the antennas, cutting into performance. Rosen was asked to help troubleshoot.

He determined that the satellites could be positioned in ways that the sun's intensity would boil off the lead residue. It was a delicate operation, needing to be done just right so as not to hamper the satellite's antenna reflector. It was a clever solution.

"He always has these great concepts," said Craig Cooning, president of Boeing Network & Space Systems, "to provide that creative spark to our engineers. He doesn't complicate things."

A prodigy at a young age, Rosen graduated from high school in New Orleans when he was 15 and worked on top-secret radar and sonar systems as a naval electronics technician at 18. He developed an interest in space technology and exploration as a graduate student while pursuing master's and doctorate degrees at the California Institute of Technology.

His education and military background took him to Raytheon, where he developed early anti-aircraft guided missiles, and then for Hughes, where he helped launch the world's largest communications satellite

Photos: (Far left) Harold Rosen, right, with scientist Thomas Hudspeth and the Syncom prototype at the top of the Eiffel Tower during the Paris Air Show in 1961. **BOEING ARCHIVES** (Below) Harold Rosen still lends his expertise to the satellite industry and recently helped solve an antenna interference issue. **PAUL PINNER | BOEING**

business. He later formed Rosen Motors with his brother, Ben, and developed a prototype hybrid electric powertrain for automobiles. He holds more than 80 patents, most of them related to satellites.

"The U.S. Navy years were very important years for me," he said. "The Navy taught you how to maintain newly acquired electronics, which were secret at the time and amazing at times. It got you to the point where they gave you a piece of equipment that had failed, and you diagnosed it, repaired it and put it back together real fast. It was hands-on practical experience. That, combined with my education, led me to have confidence. I still have that confidence."

Rosen went on to direct the development of more than 150 communications satellites before retiring as a vice president in 1993.

In a 2008 interview for a feature about Syncom in *Frontiers*, Rosen said the proudest moment of his career, at Hughes and later Boeing, came at the NBC studios in Burbank, Calif., when he watched the first live broadcast of the 1964 Olympic Games from Tokyo—made possible by the two Syncom satellites orbiting Earth.

"At the end of such a struggle it was a moment where I was really proud," he

recalled in that interview.

Today, Rosen works two days a week as a Boeing consultant. He meets monthly with Cooning and is always armed with paperwork filled with sketches and different schematics. He has plenty of new ideas to share.

Rosen also tries to maintain a high level of physical fitness. An Internet video shows him on a California beach, impressively swinging through a ring circuit and back. He bounces on a trampoline at home. He talks of some day becoming the world's fastest centenarian runner. He's counting on others to discover a life extension for him.

"I'm hoping people working on anti-aging devices speed up their act," he said.

Rosen has plenty of new challenges to address. Besides offering his satellite expertise, he's looking for ways to detect and use gravitational waves, bring more water to Southern California, use climate engineering to cool the planet, and deliver the Internet to those who don't have it.

He is convinced people should be connected, which was his initial premise when he came up with the idea for Syncom. It's good for the planet, he said. Give everyone the Internet and who knows where it might lead.

"What I find interesting about him is, even today, he's coming up with concepts and ideas that provide value overall," Cooning said. "A lot of times he'll come up with things so fundamental and simple, and you look at it and say, 'Why couldn't we think of that?'"

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Know of any Boeing or heritage company trailblazers you'd like to see interviewed in future issues of *Frontiers*? Send suggestions and a brief note about their contributions to boeingfrontiers@boeing.com.

Photos: (Left) One of the challenges Harold Rosen has taken on is connecting everyone in the world to the Internet, which was his initial premise for Syncom. **PAUL PINNER | BOEING** (Below) Rosen celebrates the 10th anniversary of the launch of Syncom, which became operational in 1963. **COURTESY OF HAROLD ROSEN**

MILESTONES

معاً، نستثمر

تفخر بوينج بكونها شريكاً رائداً في دعم قطاع التعليم السعودي، حيث ساهمت الشركة بتأسيس جامعة الفيصل في مدينة الرياض، بالإضافة إلى دعمها أبحاث طلاب الجامعة في مختلف المجالات مثل الهندسة والعلوم وإدارة الأعمال والطب.

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