

Frontiers



Growler pride

Electronic warfare:
A visit with U.S. Navy flight crews
who operate Boeing's EA-18G



PHOTO: BOEING ARCHIVES



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Cover: The EA-18G Growler is prepared for flight at Naval Air Station Whidbey Island in Oak Harbor, Wash. **BOB FERGUSON | BOEING**

Photo: (Above) As the sun rises, U.S. Navy ground crew prepare a Growler for a training flight. **BOB FERGUSON | BOEING**

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Celebrating educational efforts in India, this ad was developed to launch Boeing's new "Together. Building the Future" advertising campaign. The theme focuses on the partnership between Boeing and India, working together to create a better future.



This ad features Boeing Commercial Satellite Services, a full-service provider of global broadband connectivity. It appears in trade publications.

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Build a Better
PLANET

LEADERSHIP MESSAGE

Marc Allen

Boeing senior vice president
President, Boeing International



Sparking the imagination

Paris Air Show is a time to reflect on Boeing's trailblazing journey in aerospace as the company approaches its second century

An air show encounter more than 100 years ago was the spark that fired the imagination of Boeing founder William E. Boeing, a visionary with a global perspective.

Fluent in English, German and French, Bill Boeing had global horizons. He was born in Detroit to a German father and an Austrian mother, and sent to Switzerland for boarding school.

In 1910, six years before starting his company, Boeing, then 29, traveled from Seattle to an international air show in Los Angeles, where he encountered famed French aviator Louis Paulhan. With his background and broad imagination, Boeing quickly grasped the profound implications of the new industry.

Marveling at Paulhan's aerial feats and the new technology on display, Boeing tried but failed to get a ride in Paulhan's Farman biplane. He went home to Seattle determined to pursue aviation.

This June, we at Boeing find ourselves at Le Bourget Airport for the biennial Paris Air Show, the world's largest and longest-running aerospace trade show. It offers a timely opportunity to step back and marvel at our position in the world.

The company approaches the

beginning of its second century in an incredibly competitive environment. Our aim is to sustain our global aerospace leadership and endure as an industrial champion by being the strongest, best and best-integrated aerospace company in the world. That will require leveraging the resources of the world, building a leadership position in operations, partnerships and suppliers on a global basis.

I'm pleased to attend the air show as Boeing International president. Our team has the privilege to serve the company and its business units on the front lines of the international growth imperative.

In-country teams represent the company to local stakeholders, integrate enterprise elements and strategies for "One Boeing" business and functional excellence, and carry out assignments for the business units with local capabilities—all of which are invaluable for getting things done all around the world.

The company's global footprint continues to grow. Our non-U.S. operations and subsidiaries now exceed 20,000 employees. We maintain corporate offices in 17 non-U.S. regions.

In-country teams continually develop new supplier, business and technical partnerships and integrate talent from around the world. The efforts are developing revenue opportunities through partnerships and reducing costs through leveraged resources.

Aerospace has always brought people together around shared human aspirations. Today, the draw is greater than ever, thanks to economic development in rising economies and new technologies. The changes are reshaping the world—again. While we have Bill Boeing to thank for getting us started, we have the chance to carry on his legacy in the face of this change.

Each year, we celebrate through the Global Month of Service a core value that our founder Bill Boeing brought to the company. Employees outside the United States volunteer their time and talents to improve their communities, serving in spirit alongside U.S. colleagues who are doing the same. This joined effort is a great reminder that our global partnerships are not just building a business but also growing Boeing as a contributing citizen of the world. ■

PHOTO: BOB FERGUSON | BOEING

SNAPSHOT

Celebrating the Dream

Streamers shower an American Airlines 787 Dreamliner during a welcoming ceremony at Dallas–Fort Worth International Airport in late April. It was the first opportunity for many of the airline’s employees to see and tour the Dreamliner. American Airlines, which ordered more than 40 of the fuel-efficient jets, began 787 passenger service last month. PHOTO: DOUG ALDER | BOEING





QUOTABLES

“All of us feel rejuvenated—like it’s a new career. I’ll be 59 years old and feel like a kid again every time I fly it.”

—Mike Riley, a captain for American Airlines, talking about the airline’s new 787s. (See photo, left, of airline employees celebrating the delivery of one of their Dreamliners.) *Boeing News Now*, April 30

“The Growler is the new hotness. Everybody wants to fly it.”

—U.S. Navy Lt. Cmdr. Marcus K., a Growler pilot at Naval Air Station Whidbey Island in Washington state. (His full name is not used for security reasons.) For more on Boeing’s EA-18G Growler, see cover story, Page 20.

WHAT WE DO

Fit to print

This engineer is helping implement 3-D printing technology

BY ROB DIXON, AS TOLD TO DAN RALEY

As a tool engineer for Commercial Airplanes in Everett, Wash., Rob Dixon finds innovative solutions to problems. In this *Frontiers* series that profiles employees talking about their jobs, Dixon explains how 3-D printing is one of the new problem-solving tools he uses.

I'm not afraid to try things. I've been trying things since I was a kid. I like to say "fail fast" because sometimes we fail too slowly and we drag things out. We need to fail as fast as we can so we can move onto something that works.

For two years, I've been a tool engineer on the TRACC (Tooling Rapid Action Change Cell) team at the Everett plant. My job has evolved into inventing. There are six of us. We try to solve hard problems. We use 3-D printers that create prototypes and products for manufacturing. They have one like this up in the International Space Station.

Here's how it works: The customer will bring us a problem and an idea about how to fix it. As a team, we work on a solution and come up with a CAD (computer-aided design) model. A file is sent to the 3-D printer. The printer is like a computer-controlled, hot-melt glue gun that incrementally adds layers of material to create a part. We've gone from using 3-D printers just for prototyping to also using them to fabricate tools.

We have three printers that we try to keep running all the time. I live close by, and when a machine needs to be changed on the weekend or late at night, I'll come in to accommodate the build schedule.

I have nine patents, three pending. Some involve lots of people and some just me. It's mainly clamps and clips, but one is actually an airplane part, a window-reveal design. Some of my designs are trade secrets. Most of our stuff is driven by safety, ergonomics and quality.

I grew up in Ohio, but I pursued my mechanical engineering technology degree from Montana State University because Boeing hired a high percentage of graduates from that program. I was just totally obsessed with airplanes. As far as any product of any type in the world, there's nothing that compares with a Boeing jet!

I've been successful because I don't give up. When somebody says you can't do that, it's almost like a challenge to me. I really enjoy finding something people haven't seen. Ideas are like pingpong balls. They bounce off one another. They stimulate us.

Also, I'm a TRIZ practitioner, one of a couple dozen in the company. TRIZ is a Russian problem-solving system, a tool to come up with simple solutions. One thing it does is focus on contradictions, on engineering contradictions. I use the philosophy whenever I'm thinking about something. For example, a clamp has to clamp hard but cannot clamp hard and crush the part.

My biggest goal is to help Boeing implement 3-D printing technology. Our new engineers will take this to the next level, and I train them accordingly. The printer is not going to be a solution for everything, but it is a big part of the future. Doing something that's never been done is exciting—and Boeing really has given us the tools to be creative. ■

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A man with short dark hair, wearing blue safety glasses and a light-colored striped button-down shirt, is smiling and holding a long, red, 3D printed object. The object is a drill jig with a series of circular holes along its length. The background is a blurred industrial setting.

Rob Dixon

HAS WORKED FOR BOEING:
25 years

TEAM:
Tooling Rapid Action
Change Cell (TRACC)

HAS BEEN PART OF THE TEAM:
2 years

Tool engineer Rob Dixon shows a prototype
of a drill jig created on a 3-D printer.

PHOTO: COLLEEN PFEILSCHIEFTER | BOEING

HISTORICAL PERSPECTIVE



The 'Bronc'

The OV-10 Bronco was armed, highly maneuverable—and very tough

BY MICHAEL LOMBARDI

It was built to take punishment, but it also could dish it out.

The OV-10, which served with distinction during the Vietnam War, certainly lived up to its tough-sounding name—Bronco. The innovative twin-boom, high-wing Bronco was North American's offering for a U.S. military competition to develop an observation aircraft that also could provide close support for ground troops and be used in anti-guerrilla and counterinsurgency operations.

North American Aviation, a Boeing heritage company, was selected from a field of nine competitors, and the Bronco made its first flight at the company's plant in Columbus, Ohio, on July 16, 1965—50 years ago next month.

The OV-10 was designed to be survivable. It was highly maneuverable and had excellent all-around visibility due to a large, bulbous canopy and bullet-resistant windshield. It also had self-sealing fuel cells, twin turboprop engines, dual manual flight controls and simple construction, all features that contributed to survivability. And if things went bad, the Bronco's pilot and observer were seated in tandem ejection seats that were capable of zero-speed, zero-altitude ejections.

Armament consisted of a mix of AIM-9 Sidewinder air-to-air missiles, 2.75-inch and 5-inch rockets and bombs, and gun pods loaded on the Bronco's twin sponsons that also housed four 7.62mm machine guns.

Designed for versatility, the Bronco was equipped with a compartment in the rear fuselage to carry up to 2,000 pounds (900 kilograms) of cargo, stretchers or even six very cramped paratroopers.

The Bronco served in Vietnam with the U.S. Air Force and Marine Corps, its main mission being forward air



control. The OV-10 crew would fly low and slow, and often under heavy anti-aircraft fire, to locate enemy positions and direct pilots in faster-moving fighter-bombers to those targets.

The U.S. Navy also flew the Bronco in Vietnam, borrowing 19 from the Marine Corps to equip its VAL-4 "Black Ponies" squadron that supported U.S. Navy counterinsurgency operations in the Mekong Delta.

Seventeen OV-10As were upgraded to OV-10Ds, which featured a unique night observation and target-marking system that included forward-looking infrared and laser designator/ranger. To accommodate the added weight, the OV-10D was equipped with more powerful turboprop engines and fiberglass propellers. Other improvements increased the Bronco's range and survivability.

In 1988, Rockwell, which previously had merged with North American Aviation, received a contract to update 14 D models and convert 23 OV-10As with new avionics, a new electrical system and structural improvements. The upgraded aircraft were re-designated OV-10D+ and, along with the Marines' OV-10As, were the last Broncos to see combat, serving in the Persian Gulf during Operation Desert Storm.

A total of 271 OV-10As were built, with 157 going to the Air Force and 114 to the Marine Corps. Internationally,

18 OV-10s were delivered to West Germany, 32 to Thailand, and 16 each to Venezuela and Indonesia. Broncos also were transferred from the U.S. military to the air forces of Morocco, Colombia and the Philippines. In all, North American—and, later, North American Rockwell—built 360 Broncos before production ended in 1977. The U.S. Air Force retired its last Broncos in 1991. The aircraft served with the Marine Corps until 1995.

Broncos continue to be used for civilian roles. Thirteen are operated by California's Department of Forestry and Fire Prevention as forward air controllers directing other firefighting aircraft. NASA also has operated three Broncos for a variety of research projects including acoustics and wake vortex turbulence.

Underscoring the quality of the Bronco's original design and engineering, Boeing several years ago offered an updated version with a glass cockpit, called the OV-10X, in response to the U.S. Air Force's later-terminated OA-X Light Attack/Armed Reconnaissance competition. ■

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Photos: (Far left) A U.S. Marine Corps OV-10D+ model is shown in flight, following upgrade from OV-10A configuration. **BOEING ARCHIVES** (Above) North American Aviation delivered a total of 157 OV-10As to the U.S. Air Force. **BOEING**



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‘I see, I do’

Welcome to Boeing’s new 3-D world of virtual-reality airplane design

BY DAN RALEY | PHOTOS BY BOB FERGUSON

Filled with a wall-size projector screen, a small desk and a row of chairs, the Boeing conference room looked ordinary enough. Yet once a computer was turned on and the overhead lights switched off, the workspace magically transformed into the inside of a 777X jetliner.

Intricate mechanical systems appeared in life-size dimensions, illuminated in neon shades of green, blue, red and yellow. A virtual mannequin, representing a maintenance employee, stood in front of the maze of wires, hoses and tubes, ready to perform tasks on digital command.

Adam Richardson enters this computer-simulated work area in Everett, Wash., three to four times per day—he’s largely responsible for creating it. To get there, he wears antenna-rimmed 3-D glasses that resemble something taken straight from a *Star Trek* film.

“I have the best job in the company,” said Richardson, a Boeing Research & Technology systems engineer.

The three-dimensional (3-D) world-within-a-world is referred to as IC.IDO, pronounced “I see, I do.” It’s named for vendor-supplied software that Boeing has customized.

Commercial Airplanes has multiple IC.IDO systems. In Everett, two are up and running, with a third on the way for the 777X and another for the 787; the Boeing South Carolina site in North Charleston has one for the 787, supporting the site’s propulsion systems work; Renton has two systems for the 737 and 737 MAX work; and the St. Louis site is acquiring a system to support its work statement for the 777X, according to Richardson.

Twenty years ago, the 777 was the first commercial jetliner 100 percent digitally designed and preassembled on a

Photo: Boeing Research & Technology systems engineer Adam Richardson, wearing 3-D glasses, solves 777X design problems using computer-simulated technology.

computer—resulting in a reduced reliance on expensive and time-consuming real-size mock-ups. Richardson and his team have taken the latest technological advances and customized them in an effort to design and build the next Boeing commercial jetliners as intelligently as possible while further improving employee safety during the build process.

They've shared their virtual-reality concepts with fellow engineers from design, manufacturing, tooling, reliability and maintainability, plus safety administrators, mechanics and others.

"We have some unique capabilities in terms of tools designed in-house that give us a superior advantage over our competitors," Richardson said.

IC.IDO is part of Boeing's overall push toward immersive development, or a blurring of the lines between the physical and digital worlds, and placing engineers in the design environment brings higher-quality engineering, said Terry Beezhold, vice president and 777X chief project engineer. The different Boeing sites also have the ability to simultaneously link together to conduct design reviews.

Gripping an oversize remote control, Richardson can manipulate the on-screen mannequin to reach into an extra-tight space and attempt a job-related function to determine whether it's feasible for a human to do the same. The virtual person moves as the engineer moves. By using IC.IDO, ergonomics and workplace safety risks can be assessed without putting an employee in harm's way, and costs are lowered when those risks are mitigated before entering production, Richardson explained.

For example, an early simulation of installation procedures for the thrust reverser on the 737 MAX indicated a design change was necessary. It was found that mechanics had limited-reach access and sightlines. The 3-D technology, used by a Renton team, prevented a blind installation and a costly late-stage change, and the thrust reverser installation went as smoothly as planned. Richardson is currently working on a similar issue with the 777X.



The 3-D technology also creates a sense of intrigue, continually bringing wondrous looks and curious questions from employees whenever they encounter the brightly colored IC.IDO displays splashed across a darkened room for the first time.

"It's kind of like a video game," said Josh Little, 777X manufacturing engineer. "Once you get past the cool factor—and this is amazing and cool—you get used to being in this environment and you start to do your job. It is fun, but we're serving a purpose."

Richardson's team, in cooperation with all 777X integrated product teams, will review designs for nearly

every part of the new airplane before it moves into the manufacturing phase. Decisions will be made on airplane design, the manufacturing plan, tooling concepts and ergonomics solutions that could stand for decades—and significantly affect efficiency, quality, cost and cycle time. They'll train others to use IC.IDO, too.

"We were responsible for bringing it into the company, but we're not going to own it," Richardson said. "We want other people to learn to use it, just like any other tool that's available."

Meagan Haugo, a 777X production engineer, will use IC.IDO training to concentrate on safety and ergonomics



issues, especially in wing production, which she said reports the most injuries industrywide.

“We don’t yet have a 777X wing out there in the factory,” Haugo said. But “we can use this technology to simulate the production environment to understand some of the ergonomics risks a 777X mechanic might encounter.”

The 777, designed and built in the early 1990s, used Computer-Aided, Three-Dimensional Interactive Application (CATIA) and fly-through systems that enabled engineers to simulate design geometry on a computer, reducing the need for physical mock-ups. Another 3-D system, the Integration

Visualization Tool (IVT), was used widely in 787 development and production to manipulate and analyze engineering data.

“This gives you that life-size and three-dimensional perspective that you don’t get as much from a CATIA or IVT session—it makes you feel like you’re there,” Little said.

As 3-D technology expands, the next step is to bridge the gap between what’s real and what’s virtual, according to Richardson, who joined Boeing in 2006 with a research doctorate in human factors focusing on virtual environment technology.

That might mean putting on a headset, known as a Head Mounted Display, or HMD, and navigating virtual

space rather than have a mannequin do it. Large-screen displays might become obsolete. Conference rooms would remain, well, conference rooms.

“The software is very capable and it continues to evolve,” Richardson said. “The next frontier is the interaction—of enabling more natural forms with these systems.” ■

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Photo: From left, 777X manufacturing engineer Josh Little, Boeing Research & Technology’s Richardson and 777X production engineer Meagan Haugo follow the movements of an IC.IDO virtual mannequin.



growvie

ON THE
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ERS

Boeing's electronic warfare jet detects enemy threats—and makes it an unfair fight

BY DAN RALEY | PHOTOS BY BOB FERGUSON

Bathed in a brilliant orange and yellow sunrise, EA-18G Growlers are parked in neatly arranged rows at Naval Air Station Whidbey Island in Oak Harbor, Wash., up to eight across, some with canopies propped open as if in full salute.

Before the day can begin in

earnest, base personnel form long lines and perform a mandatory “FOD walk” of the expansive tarmac. They search for the tiniest foreign object debris that could be sucked into the turbofan engines.

And before the sleek, pointy-nosed jets can take to the skies, ground crew drop to their knees whenever the

Photo: The “FOD walk” is a morning ritual at Naval Air Station Whidbey Island where lines of pilots, ground crew and even civilian employees scour the flight line for foreign object debris that could be harmful to jet engines.



engines roar to life and perform an obligatory inspection. They look for changes of color in the exhaust that might signal a problem.

Much care is given the twin-tail U.S. Navy jets before they embark on daily operations, which are counted by base landings and touch-and-go maneuvers, often with a dual flash of bright yellow afterburners on display.

Everything about the Boeing-made Growler is precise and orderly—except when it's operating at its electronic warfare best.

In that case, success is total confusion.

The Growler's job is to trick, baffle and frustrate enemy forces however it can with state-of-the-art avionics, foremost intricate radar-jamming devices. The art of deception, using the latest technological advances, has become a huge draw for today's military aviator.

"The Growler is the new hotness," said Lt. Cmdr. Marcus K., a Navy electronic warfare officer and former Indiana schoolteacher who can't be fully identified because of security concerns. "Everybody wants to fly it."

By jamming enemy radar, Growlers help aircrews flying the F/A-18 Super Hornet and other strike aircraft reach their target without being detected. They save lives.

A modified version of the Super Hornet, the Growler is built on the same Boeing assembly line in St. Louis, with Navy orders for 153. Most of the 114 Growlers delivered to the Navy are

assigned to Whidbey Island, a windy, coastal air base that stares out at the white-capped waters of the Strait of Juan de Fuca and beyond to the Pacific Ocean. The U.S.-Canadian border is just 50 miles (80 kilometers) north. The first Growler arrived there in 2008 and its first overseas deployment came two years later. The steadily expanding fleet was the impetus behind the complete renovation of Whidbey's largest airfield hangar and the installation of a new control tower.

The Growler replaced the last of its predecessor, the EA-6B Prowler made by Grumman and retired earlier this year. The Growler is now the primary military option for an essential service—that of a disruptive electronic warfare escort for strike jets headed into combat or for ships or land forces in harm's way. Growlers are expected to be in service through 2040.

Aviation machinist mate William B., his full identity likewise concealed for security reasons, has first say on parts installations involving the Growler, which comes readily equipped to defend itself. He learned all about Navy jet engines while working 12- to 13-hour days on the flight deck of the carrier USS *Kitty Hawk*. He takes pride in the fact he can have a Growler engine swapped out in only two and a half hours. He recognizes the need for his jet's unique presence and his corresponding mechanic skills.

"I don't see a military engagement happening without the Growler," said William B., a native Texan. "We're

able to jam and military attack, and that makes me indispensable."

Most Navy pilots rarely get a chance to operate a brand-new jet over the course of their service careers, but Whidbey Island flight crews have climbed into freshly delivered Growlers and noted as few as six hours of recorded flight time. They joke about the new-car smell. They marvel at the new-age screens. They say the jet is smooth and easy to fly.

Lt. Cmdr. Stephen S. logged 1,400 hours in the Prowler before moving to the Boeing jet. The Growler makes him feel more in control in terms of enemy awareness. The Navy pilot from Illinois rattles off the names and numbers of the electronic devices now available to him and his wingman that have altered the approach to surveillance and reconnaissance, and given everyone a greater sense of comfort.

"With the old Prowler, you really weren't sure exactly where you were, you weren't sure where everybody else was and you weren't sure what the threat was," he said. "This aircraft has an incredible system that tells us where all of the threats are coming from. It locates all of the threats."

Whereas the Prowler had four crew huddled in its cramped cockpit, handling delegated chores in a prearranged fashion, the Growler has a two-person crew—the pilot and an electronic warfare officer, or EWO, in the back seat. Flight crews share and react to information gleaned



from matching computer displays and fed through a joint helmet cueing system that resembles something that Luke Skywalker might wear in the *Star Wars* films.

The Growlers go up against integrated air defense systems (IADS) and conduct suppression of enemy air defenses (SEADS). Put simply, they play an ongoing chess game with the enemy. As each side uses more sophisticated radar, weapons and communications systems, it becomes an arms race to see who can stay ahead—leading to concentrated Boeing and Navy efforts to extend the F/A-18 E/F Super Hornet and EA-18G Growler production lines in St. Louis, Mo., beyond 2017, while warning against complacency.

“The need is certainly there,” said Capt. Scott F., Electronic Attack Wing deputy commander. “When we see what our political adversaries are doing with radars, we have to make sure we have the flexibility to meet those demands of the EA-18G and the next-generation jammer. You have to make sure you have something to counter all of the threats. Everything you can do to make

Photos: (Far left) Fire extinguishers are located near each Growler as a safety precaution during servicing and engine startup. (Left) An aviation machinist mate, who can't be identified for security reasons, wears a helmet that signifies him as a plane captain. (Below) Growler afterburners flash when activated for added thrust.





it an unfair fight is critical.”

The Navy Chief of Naval Operations has publicly stated there is a Super Hornet shortfall of two to three squadrons—24 to 36 aircraft—as well as an ongoing airborne electronic attack analysis to assess the need for more Growlers to protect all U.S. military services.

To address these near-term inventory management issues, the Navy requested 12 Super Hornets as part of its fiscal year 2016 unfunded priorities list. Boeing leaders have said it is essential that Congress add Super Hornets or Growlers to the United States’ fiscal year 2016 budget to ensure that these aircraft are available for future procurement years so the Navy can meet strike fighter and airborne electronic attack needs.

The Navy’s Growlers comprise 10 carrier squadrons, three expeditionary (land-based) squadrons and one each for training and naval reserve at Whidbey Island—five jets to a group. Each is identified by VAQ, which stands for fixed wing, attack and electronic, followed by a three-digit number sequential to the other flight teams and a catchy nickname such as Yellow Jackets or Gauntlets. Squadron logos are attached to the tails of the jets. Pilots’ names are stenciled across the fuselage and maintenance leaders’ names appear on retractable landing-gear panels.

Those involved with this high-tech jet say they’re winning the invisible war. To do so, the pilots might use a squeal, static or no sound at all in jamming. Enemy radar screens could go blank or get spoofed in some elaborate manner. It’s all very clandestine—and classified.

“The limiting factor is only the aircrew,” said Lt. Eric H., who served

CONTINUED ON PAGE 29

Photo: (Left) Naval Air Station Whidbey Island borders the Strait of Juan de Fuca and is home to most of the Growlers operated by the Navy.

PHOTO FEATURE PULLOUT POSTER >

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EA-18G Growlers at sunrise on the flight line at Naval Air Station Whidbey Island in Oak Harbor, Wash.

PHOTO: BOB FERGUSON | BOEING





An EA-18G Growler stands ready prior to a dawn launch at Naval Air Station Whidbey Island in Oak Harbor, Wash.

PHOTO: BOB FERGUSON | BOEING



CONTINUED FROM PAGE 24

on a Navy nuclear submarine before becoming a pilot. “We can drop bombs and shoot missiles, but it’s a benefit to enter a military exercise where we can concentrate on jamming. We’re really good at jamming.”

The Growler aircrew often don’t get feedback on their jamming efforts until a mission is completed. They usually can’t know the electronic disruption they caused, other than having all accompanying strike aircraft return safely from the mission.

Enemy forces, however, have been known to let their frustration with the Growler slip on occasion, offering clues. Lt. Eric H. was returning from an operation overseas when he was alerted by ground-crew members that his plane’s electronic attack efforts that day had been successful. Intercepted grumbling was the confirmation.

“The mission was over and I was talking to JTAC (joint terminal air controller) support on the ground, and they said, ‘We really appreciate you and what you’re doing—we don’t know what you’re doing, but you’re really making the enemy angry,’” the New York native said. “I don’t know how they heard them.”

As technology evolves, the Growler won’t miss much. The jet soon may be able to pinpoint the location of insurgent forces hiding on the ground using little more than an intercepted cellular phone signal, according to Dan Gillian, Boeing’s F/A-18 and EA-18G programs vice president. He shared how three Growlers working together could narrow the search to a small target area, using their electronic pods to measure the time it takes for the transmissions to go from the ground to each aircraft.

The Growler’s listening capability already is an effective one and only will increase as technology matures and budgets allow, Gillian said. Over the next

Photos: (Top) Afterburners provide flash as Growlers perform touch-and-go maneuvers at Whidbey Island. (Bottom) Ground crew, who can’t be identified for security concerns, carry covers that protect the engines of parked Growlers from blowing debris and foreign object ingestion.



25 years, he added, the Navy envisions a faster and more precise electronic warfare jet, and an advanced Growler package will supply gradual upgrades. The world climate will demand it, too.

"We think there's a compelling need for more airplanes and we're working with the Navy for that need," Gillian said. "With the (electronic threat) environment, especially in 2020 and 2030, the Growler is a game changer for U.S. forces in how effective they can be."

In an article about the Growler last year in the industry publication *Aviation Week*, a Growler pilot on the aircraft carrier *USS Ronald Reagan* said Growler flight crews are only now starting to tap into the incredible capabilities offered by the aircraft.

"I don't think we've even cracked the nut yet on how much Growler can do," this veteran Navy pilot was quoted as saying. "In a classified discussion, it's eye-watering. The bumper sticker here is that the Navy does evolutionary stuff very well—and the Growler is evolutionary."

To operate this marvel of technology, a Navy pilot typically receives basic flight training in Pensacola, Fla., advanced training in Meridian, Miss., or Kingsville, Texas, and 42 weeks of Growler training at the Whidbey Island base. The Growler and its bank of systems, according to the Whidbey pilots, require someone with an analytical mindset who is capable of multitasking and problem-solving. Most important, an aviator must be open to

learning new things to be proficient.

"You don't have to be macho to fly this airplane; you have to be a nerd," said Lt. Paul L., a naval electronic warfare officer who grew up attending air shows in Wisconsin. "We deal with electromagnetic spectrum at length. We're a bunch of nerds."

At the same time, the Growler comes fully equipped to engage in battle and will defend itself if necessary. Among its weaponry is the HARM, or high-speed, anti-radiation missile, which weighs 1,000 pounds (450 kilograms) and doesn't go unnoticed.

"When ordnance comes off the aircraft it's pretty spectacular," Lt. Cmdr. Marcus K. said. "I've done air-to-air and air-to-ground missiles shoots and the HARM itself is like a telephone pole coming off your jet. It sounds like a banshee coming off."

Well after delivery, Boeing still has a hand in keeping the Growler airborne and operating efficiently. A five-person team of field service representatives is assigned to the Whidbey base. They're former military personnel who, with more than five decades of combined avionics experience, make daily house

Photos: (Above) Growlers have folding wings, which enable them to park in tight spaces when deployed on aircraft carriers. (Right) A Navy maintenance employee, who can't be identified for security reasons, performs cockpit checks before the Growler leaves on a training flight.





calls on hangars, offices and ground crews. They provide overall support, training and troubleshooting.

Asked about a single-engine startup by Navy mechanics, Enrique Echevarria, a Boeing employee for 13 years and a former Marine, had an immediate answer. He didn't need to consult a manual; he recited the information off the top of his head. He and his colleagues are able to track down elusive parts or call Boeing's St. Louis site direct for a solution. Each person brings an area of expertise.

"We're like the free 1-800 number for your Honda," Boeing field service rep Stokes Kenner said.

Electronic warfare has been the sole domain of the Navy since 1995, when the U.S. Air Force offered up the responsibility. The Growler, however, remains a shared aircraft. American and Australian air force pilots fly joint-force training operations with their naval counterparts in order to stay abreast of the latest jamming developments or to operate these jets independently in the future.

U.S. Air Force Maj. Ajay G. flew Boeing's B-1 Lancer bomber before getting assigned to the Growler as an electronic warfare officer. With its maneuverability and cockpit openness, the newer jet gives

him more of a sense of empowerment, if not unobstructed sightlines.

"I'm flying the latest and greatest," the Massachusetts native said. "The view in the B-1 cockpit is isolated, like there's a small airliner window, but I have a bubble canopy now, a 360-degree view, and you really feel like you're flying with an aircraft that you can strap on."

Australia is the first international customer for the Growler. The first of 12 Growlers is scheduled for delivery this summer. The Growlers will join the Royal Australian Air Force fleet, which includes 24 Super Hornets in operation, in 2017.

A half-dozen Australian pilots have



been training at the Whidbey Island base and evaluating the jet, offering suggestions as to how it might perform in their home environment.

“It’s a fantastic privilege to share on the platform that the Americans have built,” said an Australian flight lieutenant, also unidentifiable for security reasons. “I think it says a lot about our ability, that they trust us enough. I’m still trying to get my head around what this airplane can do. It’s so capable, so different.”

At Whidbey, the Growler is almost always in motion, taking off and landing, continually testing itself and its crews for any eventuality. Pilots conduct six

hours of preparation for a regular day maneuver and 12 to 15 hours for a large-scale exercise, all for missions that last at least 90 minutes each. It’s a lot of work. Yet they need to be mobile should there be an international flare-up that demands an immediate presence elsewhere.

The EA-18G has become a great protector for America and its allies, energizing the airmen who fly it while giving everyone else a sense of calm, in the face of a changing world.

“This country,” Lt. Paul L. said, “is a lot more relaxed with this airplane.” ■

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Thanks to Stephanie Bass and Robert Papadakis for their help with planning and coordinating this story.

To learn more about Boeing’s Growler and Super Hornet, and to encourage Congress to add aircraft to the United States’ fiscal year 2016 budget, employees can visit <http://fa-18.com>. Employees who choose to participate must do so on their own time and in compliance with company policy.

Photo: Exhaust diamonds show as a Growler retracts its landing gear and starts to climb at Naval Air Station Whidbey Island while performing touch-and-go maneuvers.



Gateway = T

Turkey is an important partner with Boeing for its commercial and defense needs

BY ERIC FETTERS-WALP

The nexus between Europe and Asia has been a center of trade and culture for millennia, and that remains true as the Republic of Turkey advances through the 21st century.

Aviation is an important part of modern Turkey's growing economy, including a new airport under

construction in Istanbul that aims to be the world's largest. Turkish Airlines, the nation's flag carrier, flies to more nations than any other airline in the world, while maintaining award-winning service.

With the country's status as a NATO member, Turkey's armed forces operate dozens of Boeing and heritage company military aircraft, ranging from the F-4 fighter to the Peace Eagle Airborne Early Warning & Control system. The military also has the latest "F" model of the Chinook helicopter on order.

"Turkey matters for Boeing because



o = growth

of our long-standing partnership on both the commercial and defense sides of the business. It's one of those countries where we really can offer all the capabilities of 'One Boeing,'" said Marc Allen, president of Boeing International. "It's also a good growth market. It's a gateway country that links Europe to the Middle East, and, as a result, it's benefiting from the strong growth in the Middle East."

As Turkey's business with Boeing has flourished, so has Boeing's involvement with the country.

Boeing runs offices in Ankara and Istanbul and Boeing programs support almost 2,500 jobs in various Turkish companies, according to Bernie Dunn, president of Boeing Turkey and North Africa. Across the nation, Boeing-supported educational,

Photo: The red and white livery of two Turkish Airlines 777-300ERs (Extended Range) awaiting delivery frame the view from the Delivery Center in Everett, Wash., in March. The airline took delivery of its 125th Boeing jetliner in May. **GAIL HANUSA | BOEING**



cultural and health projects reach people in dozens of Turkish cities.

“We are proud to partner with Turkey in strengthening the local aerospace industry, and we continually collaborate toward that goal,” Dunn said. “Growth of the Turkish aerospace industry is a win-win opportunity, meaning growth both for Turkey and for Boeing.”

The nation’s commercial aviation market is dominated by Turkish Airlines, which has a history with Boeing that dates back 70 years, when the airline received its first DC-3 from Douglas Aircraft, a Boeing heritage company. In 2013, Turkish Airlines received its 100th direct delivery from Boeing, a 737-800. The carrier operates a large fleet of 777-300ERs (Extended Range) and 737s. The airline’s emphasis on customer service has earned it several Skytrax awards for Europe’s best airline and the world’s best airline in recent years. The carrier also was selected as Airline of the Year by *Air Transport News* in 2013.

In the past three years alone, Turkish has ordered 20 Next-Generation 737s, 50 737 MAX jetliners and 20 777s. Additionally, the airline’s Turkish Technic subsidiary operates a world-class maintenance center for 737 airplanes.

“Turkey is a fantastic tourist destination with dozens of cultural and historically significant sites across the nation,” said Chris Morgan,

Commercial Airplanes Sales director for Turkey. “But it is also a very modern nation that has experienced significant growth over the past decade, and Turkish Airlines has been a beneficiary of this. We’re looking forward to continuing our support of Turkish Airlines’ plans for profitable growth at this important juncture in its history.”

SunExpress, a joint venture of Turkish Airlines and Lufthansa, also has 737 MAX and Next-Generation 737s on order, and Boeing has developed a customer relationship with Pegasus Airlines. Boeing is the largest provider of commercial airplanes to Turkey.

“Our intent is to remain there,” Allen said of being No. 1 in airplane deliveries to Turkey. But he added that the competition is “furiously trying” to change that.

Turkey’s armed forces fly Boeing KC-135 aerial tankers and F-4 Phantom fighters, the latter built by heritage company McDonnell Douglas. Turkey also has Boeing’s Harpoon antiship missiles.

This year marks the Turkish air force’s receipt of its fourth and final Peace Eagle, the Airborne Early Warning & Control (AEW&C) aircraft based on the 737 platform, said Mark Ellis, director of Airborne Surveillance, Command and Control. It features a multi-role electronically scanned array radar. Next year, Turkey is

scheduled to receive its first CH-47F rotorcraft, with 10 more to follow in the coming years.

Allen noted that military services offers an area for growth in Turkey. Boeing already is providing periodic depot-level maintenance for Turkey’s KC-135 tankers, which includes training Turkish air force personnel how to provide those services in the future. Boeing also works with Turkish Technic to perform depot-level maintenance of the 737 AEW&C Peace Eagle fleet.

Those maintenance partnerships

Photo: Boeing delivered the first of four Airborne Early Warning & Control aircraft, shown, to Turkey last year. Based on the Boeing 737-700 airplane, the aircraft provides advanced airborne surveillance and battle management capabilities and can simultaneously track airborne and maritime targets. **BOEING**



TURKEY AT A GLANCE

Official name	Republic of Turkey
Capital city	Ankara
Area	302,535 square miles (783,560 square kilometers)
Population	81.6 million (estimated in 2014)
Gross domestic product	\$1.167 trillion (estimated in 2013)

SOURCE: U.S. GOVERNMENT

with the military are examples of the cooperative agreements Boeing has with Turkish aerospace companies for both commercial and defense. Turkish Aerospace Industries and Kale have participated in all of Boeing's commercial airplane programs since 1997, while PFW provides parts for the 787 and Turkish Technic provides technical and maintenance services for several Boeing models. Turkish companies also work for the Peace Eagle program and contribute to other Boeing military aircraft models.

"Our work with the suppliers there is important. It's been a great opportunity for us to help contribute to Turkey's national development in relation to aerospace," Allen said.

With that in mind, Boeing and Istanbul Technical University are collaborating in aerospace technology research, with a special focus on advanced cabin air-filtration systems. In tandem with Turkish Airlines, Boeing and the university also have established a master's degree course in air transport management to support the growth of the aerospace sector in Turkey. Additionally, Boeing provides competitive scholarships to Istanbul Technical students, alongside faculty grants for the university's academic staff to help develop aeronautical engineering curriculum. This year, Boeing and Istanbul Technical also are partnering on an unmanned aircraft design competition for Turkish students.

At Anadolu University Faculty of Aeronautics and Astronautics, Boeing is contributing to curriculum enrichment. The company also helped establish a composite laboratory at Ege University and an aircraft maintenance workshop at a vocational higher school in Izmir. Boeing provides competitive U.S.-based internships every year for aspiring Turkish university students.

Since contributing to the relief efforts after Turkey's devastating earthquake in 1999, Boeing has expanded its Global Corporate Citizenship efforts in the nation. In

the area of education, Boeing has supported more than 130 projects in 39 different cities. Working together with local nonprofit organizations such as ACEV (Mother Child Education Foundation), TEGV (Educational Volunteers Foundation of Turkey) and LOSEV (Foundation for Children with Leukemia), Boeing supports early learning, primary- and secondary-level education, parental education, and health education programs in disadvantaged regions of Turkey.

With assistance from Anadolu University, Boeing also supports vocational training of teachers and language training of students at high schools that teach aircraft maintenance and related technical skills. In partnership with local nonprofit agencies, Boeing supports initiatives and programs to enhance entrepreneurial and job skills of Turkish youth.

Boeing also supports archeological excavations in several Turkish sites, with a view to contribute to Turkey's efforts toward unveiling the rich cultural heritage in the country. As Boeing's relationships with customers, suppliers and educational institutions continue to grow, its support for projects such as these across Turkey also is destined to grow, according to Filiz Hayirli Tepebasi, associate director for Strategy, Industry and Government Relations in Turkey.

"Social responsibility is an integral part of our efforts to tie Boeing's name to Turkey's development goals," she said. "Our focus is on empowering people as the most important resource for achieving sustainable social impact. It is amazing to touch the lives of people all around the country every day through our programs and contribute to positive change." ■

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Photo: A teacher interacts with children at the Diyarbakir Alipasa Family and Child Education Center, which is run by ACEV (Mother Child Education Foundation) in Diyarbakir, Turkey. Boeing helps fund education programs at the center. JASON LAU | ACEV





East meets West

Taiwan's flag carrier introduces innovative interior on its newest Boeing jetliners

BY KEVIN YOO

With five new 777s in service and another five in the production pipeline, China Airlines has staked a good part of its future on the safety, range and fuel efficiency of Boeing's largest twin-engine jet. The Taiwanese flag carrier has said it expects each of its 777-300ERs (Extended Range) to shave nearly \$10 million off of its annual operating costs.

But it's what's inside the airline's flagship fleet of 777-300ERs that has captured the design world's attention.

The cabin interior, designed by Taiwanese architect and designer Ray Chen, is the centerpiece of an ambitious airline rebranding that aims to provide passengers with a philosophical journey from East to West. Called "NexGen," the makeover covers everything from cabin amenities to crew uniforms and exclusive dinnerware.

Chen, who heads the effort, said he tried to capture China Airlines' "brand essence and evolution" by using

the cabin as a canvas for Taiwan's culture and history. For inspiration, he drew from Lu You, a poet of China's Song Dynasty (960–1279 AD).

Amenities on board these new 777s include persimmon-wood paneling, mood lighting, artwork on lavatory

walls, a Premium Business Class Sky Lounge and 10 rows of fold-down Family Couch seats in economy class.

"The new interior," Chen said, "demonstrates the reinterpretation of classic aesthetics through the Taiwanese lens."

China Airlines, which received its first 777 last fall, began pursuing a new approach to cabin design to distinguish itself in the highly competitive Asian marketplace, said Huang-Hsiang Sun, airline chairman.

"In addition to enhancing safety and fuel efficiency, we are incorporating





CUSTOMER PROFILE



Taiwan's cultural creativity into our cabin interiors," Sun said. "I am confident this will leave a lasting impression on passengers and enhance our competitiveness."

The airline is banking on the success of its "NexGen" strategy and plans to have Chen design new cabin interiors for other airplanes joining its fleet, such as the Airbus A350.

The airline's five newly configured 777s are used on routes serving Hong Kong, Shanghai, New York and Los Angeles. From July, China Airlines will launch the 777-300ERs on the Taipei-San Francisco route as well, followed by the Taipei-Frankfurt route in November.

Based in the northwestern city of Taoyuan, China Airlines is Taiwan's largest carrier, with 115 destinations in 29 countries and regions worldwide. The airline operates more than 100 flights weekly from mainland China to Taiwan, and that number is expected to grow as liberalization of rules and regulations continues, allowing more mainland Chinese tourists to fly into and through Taiwan.

The airline expects to have one of its 777-300ERs at the Paris Air Show this month. Plans call for a static display of the airplane and virtual, 3-D tours of the NexGen interior, which

To view a video of Ray Chen talking about his design for China Airlines, visit boeing.com/frontiers/video/june15.

drew heavy media coverage after its debut last fall. Yahoo Travel called it "a tastefully decorated treat."

Premium Business Class passengers enjoy flat-bed seats and access to the Sky Lounge, a high-ceiling space for conversation and refreshments. Designed as a fusion of East and West, the lounge features a "Literary Tea-Tasting Area" on one side, a Western "Fashionable Coffee Area" on the other side, and cocktails and tapas in the middle. Bookshelves offer a rotating selection of Chinese and English books, which, according to China Airlines' website, "immerses busy passengers in a relaxing setting of literature and taste."

Ihssane Mounir, senior vice president of Commercial Airplanes Sales for Northeast Asia, said it's an honor for Boeing to have the

777 play such an integral role in the airline's long-term success.

"China Airlines has raised the bar in terms of passenger experience and comfort with their new cabin design," Mounir said. "Their NexGen philosophy will enhance their brand image, while their innovative cabin interior will capture the hearts of many travelers around the world as they continue to expand into new markets." ■

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Photos: (Clockwise from top left) China Airlines' Premium Business Class features ergonomic memory-foam cushion seats with 180-degree lie-flat capability. **CHINA AIRLINES** A China Airlines 777-300ER (Extended Range) takes off from Paine Field Airport in Everett, Wash. **TIM STAKE | BOEING** The airline's Sky Lounge provides Premium Business Class passengers a taste of Taiwan through a variety of local teas and pastries. **CHINA AIRLINES**

VISIO

With just a turn of the head, digital helmet system zeros in on target

BY RANDY JACKSON

As the Advanced F-15 taxied to a stop at Boeing's flight-test facility in the high desert near Palmdale, Calif., test pilot Dan Draeger gave a thumbs-up through the polished canopy. His face was partially hidden by the large reflective visor on his flight helmet.

The F-15 had just spent more than three and a half hours in the skies over Southern California and the Pacific Ocean, while Draeger and a U.S. Air Force weapons systems officer, seated behind Draeger, tested and evaluated a new high-tech helmet and visor.

"This definitely brings some great capabilities to the cockpit," Draeger, Boeing Test & Evaluation chief F-15 test pilot, said after he climbed out of the air superiority fighter.

The next-generation helmet uses digital technology and eventually will replace the analog technology currently used in the Joint Helmet Mounted Cueing System



NARY



(JHMCS). The current helmet, which lets aircrews control sensors to more quickly and easily acquire and “lock-on” to targets simply by looking through a special visor on the helmet and pushing a button on the control stick, is used by more than 20 air forces worldwide.

Before the Joint Helmet Mounted Cueing System was developed, fighter pilots had to turn their aircraft toward a target. Now, they just turn their head.

“The JHMCS changed the way pilots and weapon systems officers performed their missions when it was first introduced,” Draeger said, “and this digital version takes what that helmet did and multiplies it tenfold.”

Engineering teams from Boeing and Rockwell Collins–ESA Vision Systems spent about three years developing the digital system and preparing for the March test flight at the Boeing Test & Evaluation facility in Palmdale. Boeing is responsible for integrating the helmet

Photo: The new Digital Joint Helmet Mounted Cueing System, shown with daytime visor down, provides advanced targeting and mission capabilities to aircrew. **RANDY JACKSON | BOEING**



and technology into tactical aircraft.

"This is the first major upgrade to the joint helmet system, which was first fielded 15 years ago," said Greg Hardy, manager for Boeing Tactical Aircraft Advanced Display Systems in St. Louis. "The technology is revolutionizing air combat."

The digital system uses less power and has fewer parts in the helmet and cockpit, making it more reliable, Hardy said. Its mass also is better balanced to reduce pilot fatigue, critical during acceleration and high G-force maneuvering. In addition, the day visor can be swapped out quickly by hand, allowing the aircrew to easily move between day and night operations.

"Couple this technology with a sharper image and improved day and night capabilities ... and you have an advanced targeting solution that is more reliable and less fatiguing for pilots to wear," Hardy said.

The Digital Joint Helmet Mounted Cueing System uses an organic-light-emitting-diode display, which improves maintenance and reliability, Hardy added. Sensors it can integrate and control

include infrared search and track, radar, and multi-spectral targeting pods.

During the March evaluation test flight, Draeger and his weapons systems officer (WSO) closed in on two small targets in the Pacific Ocean off the California coast. Both were extremely hard to find with the naked eye, but not a challenge with the helmet's ability to guide the operator's eyes to the targets' exact locations.

"The helmet visor allowed us to lock-on the targets just by looking at them, and it provided us with information about those targets," Draeger said. "Even through clouds, you get range and direction to target in seconds."

Before the Joint Helmet Mounted Cueing System, he added, it might have taken minutes to find the target, if at all.

The new system not only helps both the pilot and the weapons officer track targets by simply moving their head, but the pilot can "see" where the weapons officer is looking.

"If the WSO says he's looking at the third building on a street, all I have to do is follow the symbol on my visor to

see what he's looking at," Draeger said.

"In the old days before JHMCS, that conversation might have taken over a minute, and I still might not have gotten my eyes on the right target. Today, it takes as long as it takes to turn my head."

The digital system also allows aircrews to quickly share the targeting workload and hand off attack duties to one another. And it has a high-resolution camera that records what the pilot and weapons officer sees, for post-mission debrief.

"You can't give the warfighter too many tools," said Mike Gibbons, vice president, Boeing F-15 programs. "Our mantra here in the F-15 program is extending the life, extending the capability—to keep the jet not only relevant but dominant over threats for decades to come. ■"

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Photo: A Boeing Test & Evaluation test pilot fitted with a new Digital Joint Helmet Mounted Cueing System readies for flight in an Advanced F-15 air superiority fighter. **RON BOOKOUT | BOEING**

MILESTONES

IN FOCUS

Extended vision

An Airborne Warning and Control System (AWACS) aircraft operated by NATO is refueled by a KC-135 tanker from the Utah Air National Guard over Germany in January. Boeing is in the middle of a multiyear upgrade on NATO's fleet of 14 AWACS aircraft that will modernize them with digital cockpits and up-to-date avionics, replacing 1970s-era analog systems. Boeing built the AWACS, which is based on its 707 jetliner platform.

PHOTO: CAPT. ANDRÉ BONGERS | NATO PUBLIC AFFAIRS OFFICE, GERMANY





A satellite is shown in space, emitting a bright, glowing beam of light that extends down to Earth. The beam is composed of many parallel lines, creating a sense of depth and connection. The Earth is visible in the background, with a colorful, iridescent glow around it. The overall scene is set against a dark, starry space background.

A SECURE CONNECTION FOR SECURE GLOBAL BROADBAND.

Boeing Commercial Satellite Services (BCSS) provides ready access to the secure global broadband you need. Working with industry-leading satellite system operators, including a partnership to provide L- and Ka-band capacity aboard Inmarsat satellites, BCSS offers government and other users an affordable, end-to-end solution for secure bandwidth requirements. To secure your connection now, visit www.GoBCSS.com.

